Trawl Survey for Thornyhead Biomass Estimation off the West Coast of Vancouver Island, September 15 - October 2, 2001

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V9T 6N7

2002

Canadian Technical Report of Fisheries and Aquatic Sciences 2421

Fisheries and Oceans Canada | Pêches et Océans Canada

Canada

Canadian Technical Report of
Fisheries and Aquatic Sciences

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Fisheries and Aquatic Sciences 2421

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TRAWL SURVEY FOR THORNYHEAD BIOMASS ESTIMATION OFF THE WEST COAST OF VANCOUVER ISLAND, SEPTEMBER 15 - OCTOBER 2, 2001

by

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Cat. No. Fs 97-6/2421E ISSN 0706-6457

Correct citation for this publication:

Starr, P. J., B. A. Krishka, and E. M. Choromanski. 2002. Trawl survey for thornyhead biomass estimation off the west coast of Vancouver Island, September 15 - October 2, 2001. Can. Tech. Rep. Fish. Aquat. Sci. 2421: 60 p.

ABSTRACT

Starr, P. J., B. A. Krishka, and E. M. Choromanski. 2002. Trawl survey for thornyhead biomass estimation off the west coast of Vancouver Island, September 15 - October 2, 2001. Can. Tech. Rep. Fish. Aquat. Sci. 2421: 60 p.

A bottom trawl survey was conducted from September 15 to October 2, 2001 to estimate relative thornyhead biomass off the west coast of Vancouver Island. The *F/V Viking Storm* was chartered to complete the first year of a 3-year survey that used a random survey design stratified by region and depth. Biological information was gathered from 16 species including longspine thornyhead (*Sebastolobus altivelis*), shortspine thornyhead (*Sebastolobus alascanus*), sablefish (*Anoplopoma fimbria*), Dover sole (*Microstomus pacificus*), deepsea sole (*Embassichthys bathybius*), arrowtooth flounder (*Atheresthes stomias*), roughscale rattail (*Coryphaenoides acrolepis*), pectoral rattail (*Albatrossia pectoralis*), skates and rockfish. Ninety-nine species/groups were collected from 63 tows, and 58 of these tows were usable for biomass estimation. Bottom contact sensors were used to refine effort estimates compared to traditional methods where tow time equaled time from winch lockup to winch release. Biomass estimates for the top six species captured within the trawlable portion of the survey area included roughscale rattail (8,200 t), sablefish (5,900 t), pectoral rattail (4,900 t), longspine thornyhead (4,600 t), shortspine thornyhead (2,200 t) and Dover sole (1,200 t). Estimates of precision for most of the major species taken in the survey were generally less than 15% relative error. This level of survey precision indicates that there is good potential for indexing these species in future assessments, particularly for longspine thornyheads because the full species depth range was covered in the survey.

RÉSUMÉ

Starr, P.J., B.A. Krishka, and E.M. Choromanski. 2002. Trawl survey for thornyhead biomass estimation off the west coast of Vancouver Island, September 15 - October 2, 2001. Can. Tech. Rep. Fish. Aquat. Sci. 2421: 60 p.

Un relevé au chalut de fond a été effectué du 15 septembre au 2 octobre 2001 pour estimer la biomasse relative des sébastolobes au large de la côte ouest de l'île de Vancouver. Le *F/V Viking Storm* a été affrété pour la première année d'un relevé aléatoire prévu sur trois ans, stratifié en fonction des zones et des profondeurs balayées. Des données biologiques ont été recueillies pour 16 espèces dont le Sébastolobe à longues épines (*Sebastolobus altivelis*), le Sébastolobe à courtes épines (*Sebastolobus alascanus*), la Morue charbonnière (*Anoplopoma fimbria*), la Limande-sole (*Microstomus pacificus*), la Plie de profondeur (*Embassichthys bathybius*), la Plie à grande bouche (*Atheresthes stomias*), le Grenadier à écailles rudes (*Coryphaenoides acrolepis*), le Grenadier pectoral (*Albatrossia pectoralis*), des raies et des sébastes. Quatre-vingt-dix-neuf espèces et groupes ont été échantillonnées lors de 63 chalutages dont 58 ont pu être utilisés pour l'estimation des biomasses. Des capteurs enregistrant le contact avec le fond ont été utilisés pour améliorer la précision des estimations par rapport aux méthodes traditionnelles pour lesquelles le temps de chalutage est pris égal au temps de blocage du treuil. On a pu estimer la biomasse des six espèces les plus importantes capturées dans la portion chalutable de la zone de relevé, notamment celle des grenadiers à écailles rudes (8 200 t), des morues charbonnières (5 900 t), des grenadiers pectoraux (4 900 t), des sébastolobes à longues épines (4 600 t), des sébastolobes à courtes épines (2 200 t) et des limandes-soles (1 200 t). On estime que l'erreur relative des estimations pour les espèces les plus importantes capturées lors du relevé était généralement inférieure à 15 %. Ce niveau de précision indique qu'il existe une possibilité réelle d'indexer ces espèces lors des évaluations futures, en particulier pour ce qui est des sébastolobes à longues épines car toutes les profondeurs fréquentées par cette espèce ont été couvertes lors du relevé.

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INTRODUCTION

The continental slope of British Columbia supports commercial fisheries for numerous rockfish species. Historically, Pacific ocean perch (*Sebastes alutus*) has been the dominant rockfish species harvested, and assessment surveys focussed on either this species or the slope rockfish species complex depending upon information needs. Longspine thornyhead (*Sebastolobus altivelis*) and shortspine thornyhead (*S. alascanus*) are part of this complex, but neither species was commercially significant prior to 1996 (Starr 2001).

The establishment of a combined longspine and shortspine thornyhead fishery in 1996 along the west coast of Vancouver Island, and the northern extension of this fishery as an experimental fishery in 2000, highlights the need for biological and population information to monitor this developing fishery. Unlike Pacific ocean perch, which are found in aggregated schools, thornyheads tend to be more uniformly distributed over soft bottom (Wakefield 1990). Preliminary research planning indicated that both thornyhead species were excellent candidates for bottom trawl surveys because they were usually on the bottom and not aggregated (Schnute et al. 1999). Starr & Schwarz (2000) confirmed this conclusion for these species through analyses of catch and effort data from the commercial trawl fishery by indicating that survey precision estimates should be low.

The Canadian Groundfish Research and Conservation Society (CGRCS) subsequently funded the design and implementation of a biomass survey for longspine thornyheads. A comprehensive survey design (Appendix A) was developed after lengthy consultation with staff from the Fisheries and Oceans Canada (DFO) Pacific Biological Station, Simon Fraser University, the CGRCS, and the U.S. National Marine Fisheries Service (NMFS). DFO management staff and the fishing industry provided additional input. The survey objectives were to:

- estimate the relative abundance of longspine thornyhead lying between a southern boundary defined by the Canada-U.S. border and a northern boundary defined by Lawn Point immediately south of Quatsino Sound (approx. 50° 17' N) between the depths 500-1600 m. The target relative error (RE) of the longspine thornyhead biomass estimate is 20% ($RE = SE/\mu$) (where μ is the biomass estimate from the survey and SE is the standard error of that estimate),
- estimate the distribution by size class and sex category of the longspine thornyhead population within the extent of the survey area, given the uncertainty that results from sampling with non-representative fishing gear,
- obtain quantitative biological information from selected fish and invertebrate species.

The purpose of this report is to document the technical aspects of the cruise to assist those interested in understanding the cruise data. Biomass estimates are provided here, but they should be considered preliminary, requiring further scrutiny before a final analysis is published.

METHODS

VESSEL, STAFF AND GEAR

The *F/V Viking Storm* is a 31 m stern trawler chartered to conduct a bottom trawl survey off the west coast of Vancouver Island annually from 2001-2003. Chris Roberts and Kelly Anderson skippered the vessel. The lead scientist was Paul Starr (CGRCS). Scientific staff included Brian Krishka and Ed Choromanski from DFO, plus Dean Gaidica and Dale Pahti from Archipelago Marine Research Limited (AMR).

The survey net was an Atlantic Western II box trawl (Figure 1) that is a common design used to fish thornyheads in deep water. A 50 mm mesh codend liner captured smaller fish than would normally be taken in commercial nets. The vessel used Thyboron 107 trawl doors, standard in the deepwater fishery. A spare net of the same design was carried aboard to avoid aborting the survey due to extensive net damage or loss. The contract specified mensuration devices to record net characteristics during fishing operations.

A bottom contact sensor (provided by Mark Wilkins, NMFS) was deployed for every survey tow except for tow 10 to determine actual bottom contact time. This device measured tilt angle, with an angle of 0° indicating that the device was hanging vertically in the water and an angle of 90° indicating that the device was horizontal. The sensor was attached to the footrope of the net by a piece of short chain and we assumed that the tilt of the device indicated contact that the net made with bottom. The device measured the tilt angle every six seconds and recorded time and angle on a data logger (calibrated each morning to the time on the Global Positioning System). This information was transferred from the data logger to a computer after every tow.

SURVEY DESIGN

The design (Appendix A) that was developed prior to the survey is summarized in this section. The survey used a random stratified design with three depth strata (500-800 m, 801-1200 m, 1201-1600 m) in six regions off the west coast of Vancouver Island (Figure 2). For each of the 18 strata, Table 1 lists the total area and the reduced area available to trawl gear. Estimates of total area come from a bathymetric database (Schnute et al. 1999), and vessel master C. Roberts identified sub-areas within each stratum that could not be fished because of foul ground or steep topography. The coast was divided into 500 m^2 grid blocks that were used to identify randomly selected potential tow sites within the trawlable areas. The target frequency of tows within each region was 4 shallow / 4 intermediate / 2 deep locations. Twenty-five unique grid numbers were randomly selected within each region/depth stratum combination and each grid number was

assigned a sequential (SEQ) number from 1 to 25. The first four SEQ sites (or the first two SEQs in the 1201—1600 m strata) were then selected for fishing unless a particular site was rejected due to unacceptable depth, location, proximity or fishability criteria (see Appendix A). When an SEQ location was deemed unfishable, the next SEQ in the series was selected, unless it was also deemed unsuitable. This process was continued until four acceptable tows were completed per region/depth stratum. A total of 60 successful tows were required to complete the survey design for all region/depth stratum combinations.

The survey design specified a maximum tow time of 1 h/tow in the shallow stratum to avoid large catches of some slope rockfish species, and 2 h/tow in the intermediate and deep strata. A minimum tow time was defined as 15 to 30 minutes of actual bottom contact time, depending on the region fished, but the actual tow time was left to the discretion of the skipper. Lower acceptable bottom contact times were allowed in the northern regions to reflect the difficulty of completing longer tows along the rugged northwest coast of Vancouver Island.

Once a suitable SEQ was fished, the sampling protocol accepted tows meeting all of the following criteria:

- at least 30 minutes of bottom contact time determined by the cumulative time that the bottom contact sensor was at a tilt angle of at least 80° (reduced to a 15 minute minimum in regions E and F)
- pass within 250 m of the SEQ co-ordinates at some point during the tow (increased to 2000 m for regions E-F)
- no critical damage to the net that influenced catch

CATCH AND SAMPLE PROCESSING

Target species for biological sampling included thornyheads, sablefish, rattails, flatfish, rockfish and skates, but all catch was categorized and weighed. The procedure followed for each tow required that the total catch was emptied on deck and sorted by species into separate baskets. Exceptions included: 1) thornyheads, which required a secondary sort to separate shortspines from longspines, and 2) a mixture of invertebrates and other fish that were later sorted and identified by the sampling crew. The deck crew recorded basket weights for rattails and sablefish using hand-held spring scales. All species for which the species catch total was three baskets or less, including rattails and sablefish, would be weighed on a Marel M1100 Motion Compensated scale in the sampling area.

All specimens of the target species for biological sampling would be processed unless the total catch of that species exceeded approximately 100 fish. Whenever such large catches occurred, the target species would be sub-sampled by visually estimating the number of fish and dividing the estimated total by 100 to determine the proportion of fish to keep for sub-sampling. For example, every 6^{th} fish would be systematically selected if 100 of an estimated 600 sablefish were sampled. The vessel crew would process the remaining fish for sale if they were commercially valuable; otherwise fish were discarded.

Biological samples of length, weight, sex, maturity and otoliths were collected from thornyheads, flatfish, rockfish and sablefish. Otoliths were not taken for rattails and skates, and skate maturity was not recorded, otherwise the remaining biological attributes were obtained (Table 2). Established maturity codes were used for flatfish (Appendix B) and rockfish (Appendix C). A detailed maturity schedule does not exist for thornyheads and was therefore limited to codes 1 (immature) and 2 (mature). Tissue samples from the anterior dorsal flesh of longspine thornyheads were collected and preserved in alcohol for future DNA analysis.

Length-stratified samples of otoliths were gathered for seven key species throughout the entire survey (Table 2). The sampling crew collected length, weight, sex, maturity and otoliths from each regularly spaced length category. Total numbers sampled per length class, and size intervals depended upon the target species.

DATA CAPTURE

All bridge log, haul and sample data were recorded on standard DFO forms during the survey and checked against field notes for accuracy. Time, depth, location, distance towed, vessel speed and direction were recorded at 10-minute intervals during each tow to compensate for nonfunctional net mensuration equipment. Electronic data from the bottom contact sensor were downloaded and imported into an Excel spreadsheet after each tow to determine if that tow met the minimum contact criterion (30+ minutes in regions A-D, 15+ minutes in regions E-F). Tow track information was captured using the navigational software aboard the vessel.

The survey data have been stored in GFBio, the DFO relational Oracle database used to archive biological sample data and related information for all fishing events during research/assessment cruises. AMR was responsible for processing the field data and forwarding electronic files to DFO where the data have been loaded into GFBio (GFBio Trip ID# 42252).

Ancillary information that is archived in GFBio includes the interval bridge log data, bottom contact sensor data, skipper's tow tracks, plus two Acrobat® pdf files (this report, AMR cruise report).

BIOMASS ESTIMATION

The analytical methods for estimation of biomass and precision are detailed in Appendix D. For each species *s*, the biomass estimate (kg) was calculated as follows:

$$B_s = \sum_i C_{s_i} A_i / w \qquad \textbf{Eq. 1}$$

where C_{s_i} = mean CPUE (kg/km) for species *s* in stratum *i*

A_i = area of stratum *i* (km^2)

w = effective fishing width of net (km)

The stratum CPUE for species *s* (kg/km) equaled mean catch rate (kg/h) divided by mean tow speed (km/h). Effort was measured as either tow time (from winch lockup to winch release) or bottom contact time.

RESULTS AND DISCUSSION

The survey spanned September 15 to October 2, 2001. Chris Roberts skippered the vessel from September 15-24th and completed 45 tows in regions A-D. Skipper Kelly Anderson completed the remaining 18 tow in regions E-F from Sept. 25th to October 2nd. Paul Starr was aboard for the first four days of the survey, and was then replaced by Brian Krishka and Ed Choromanski. Ed departed the vessel on Sept. 29th. The survey concluded on October 2nd due to poor weather and lack of time before the final two tows were made in the deep stratum of region F.

Fifty-eight of 63 tows were deemed usable for biomass estimation. Basic tow information is provided in Table 3, while more detailed bridge log and haul data are found in Appendix E. Five tows were rejected due to poor bottom contact, poor net performance, failure to hit the random survey point, or incorrect random sequence (Table 4). Another 68 random tow locations were rejected during site selection: 34 (50%) locations were dropped due to poor towing conditions, 27 (40%) failed to meet the stratum definition, and 7 (10%) overlapped with other tows (Table 5).

Tow characteristics are summarized in Figure 3. Most tows traveled 4-5 km (2.1-2.7 nmi), with a minimum of 3.5 km, and one tow went over 6 km. Average tow speed was tightly clustered between 4.0 and 4.3 km/h (2.2-2.3 nmi/h) with only a few tows outside of that range. The distribution of bottom contact time for valid tows showed a strong peak at 0.7-0.8 h. The minimum contact time was 20 minutes, and three tows exceeded 1.4 h on bottom.

The ability to measure actual contact time for bottom trawls provides insight into fishing characteristics of trawl gear under various conditions. Terrain, currents, and tow speed are important factors affecting a trawl's fishing characteristics, but without net mensuration data available, our only chance to improve catch estimates depended upon bottom contact information. Numerous tows under 1.2 h had bottom time reduced by more than 50% based on sensor data (Fig. 4). Actual contact time averaged near 70% of the traditionally recorded fishing time from winch lockup-to-release (Fig. 5). As a result, biomass estimates increased considerably when CPUE was corrected for bottom contact time (Table 6). Bottom contact time was missing for tow #10, and was estimated using the mean ratio of bottom contact time: tow duration for the remaining 57 tows. The potential changes in CPUE estimates based on bottom contact sensor data are significant and warrant further investigation.

No tows were completed in the 1201-1600 m stratum in Region F (Table 3). As well, some of the tows in the 500-800 m stratum in Region F appear to have been located in the 500-800 m stratum of Region E. It was decided to combine each of the three depth strata in Regions E and F for the estimation of biomass, using all valid tows from both of the original regions.

Ten species/groups comprised most of the catch in this survey (Table 6). The most abundant species by weight was sablefish (*Anoplopoma fimbria*), followed by roughscale rattail (*Coryphaenoides acrolepis*) and longspine thornyheads (*Sebastolobus altivelis*).

This report provides estimates of biomass for thornyheads plus other species, using the analytical methods described in Appendix D. Scaling the biomass estimate to a value of 0.02 km (the width of the footrope) assumes that all fish within the width of the net are captured, and that there is no herding effect from the sweep ropes. Neither assumption is likely correct and the degree of failure will not be consistent among species. It is possible that these assumptions balance each other, but the true catchability is unknown and the biomass estimates should be compared relative to similarly collected biomass estimates. The two thornyhead species are reported to show little herding effect while Dover sole shows some herding (C. Roberts, *pers. comm.*). All biomass estimates presented in this section are based on the total catch weight in the net and do not represent the biomass vulnerable to the fishery as the codend used was smaller than that used on commercial nets.

The preliminary biomass estimates are presented in Table 7 and Figure 6. The *REs* for most of the top 12 species are well below the survey objective of 20%, including about 10% for longspine and shortspine thornyheads. These results are good, especially considering that this is the first attempt at this survey design, and are consistent with the predictions made by Starr & Schwarz (2000). Alternative methods for swept-area biomass estimation exist, such as those of Schnute and Haigh (2000) that used bootstrap techniques to assess uncertainty. Investigation of multiple estimation methods is recommended for comparison with the biomass estimates provided here.

Biomass estimates for both thornyhead species are broken down by stratum in Table 8. The smaller biomass estimates from Regions C and D correspond with less trawlable habitat compared to the rest of the survey area (Table 1). Longspine thornyheads were the only target species having most of their estimated biomass within the 801-1200 m stratum (Fig. 7). As expected, both rattail species had their largest biomass at depths greater than 1200 m, while sablefish, Dover sole and shortspine thornyhead biomass peaked at depths less than 800 m.

Biomass estimates from this trawl survey only represent that part of the population that was vulnerable to the survey gear, given the area covered. For instance, brittle stars are not well represented in this survey as this species is not very vulnerable to the survey gear. Visual observations of brittle star abundance during submarine surveillance on the Bowie Seamount suggest these organisms are quite abundant (Rick Stanley, Pacific Biological Station, Nanaimo, B.C., pers. comm.). The relative sablefish biomass is also not completely representative, as the full depth range for this species was not covered in this survey. Sablefish are known to be abundant at depths shallower than 500 m (Norris 1997).

Sixteen species were sampled for biological attributes during the survey (Table 9). Otoliths were collected from 7 target species plus 3 additional species, and DNA samples were obtained from 391 longspine thornyheads. Target species were sampled from most tows (Table 10). Biological data were not recorded for sharks, but numerous samples were taken for two skate species. Otolith sampling targets were met for both thornyhead species.

Table 11 summarizes the availability of length data for selected species on a tow-by-tow basis. Subsampling was frequently required to process larger catches of longspines (41 of 62 tows) and roughscale rattails (15 of 41 tows), while other species were occasionally subsampled. The expansion factors given in brackets in Table 11 are required to correct for subsampling and reflect the actual numbers and length frequencies for each tow.

Length frequency histograms by sex are shown in Figures 8-13 for six target species. The plots have not been scaled based on the survey design and therefore only provide the availability of specimen data by species and sex in the database. These figures also include length data from all tows, including those tows considered unusable for biomass estimation. Figure 8 illustrates the difficulty in sexing small longspine thornyheads since most specimens below 16 cm could not be sexed reliably. Similar problems were evident when sexing specimens under approximately 40 cm for both rattail species (Figs. 12 and 13).

Length-weight regressions based on Eq. 8 in Appendix D were fitted to the data for six target species (Table 12). The fitted models appear to be reasonable for five of the six species (Fig. 14). The only exception is sablefish for which the model fails to fit the smaller fish satisfactorily. For all other species caught, there are only 174 length-weight observations distributed among eight species (longnose skate – *Raja rhina*, arrowtooth flounder – *Atheresthes stomias*, rougheye rockfish – *Sebastes aleutianus*, shortraker rockfish – *Sebastes borealis*, sandpaper skate – *Bathyraja interrupta*, splitnose rockfish – *Sebastes diploproa*, abyssal skate – *Bathyraja abyssicola*, Pacific ocean perch – *Sebastes alutus*). These have been plotted (Fig. 15) but have not been fitted with length-weight models.

RECOMMENDATIONS

Numerous recommendations have resulted from the first year of this survey.

- Have a compensating scale available on deck for the sorting crew to use
- Develop a thornyhead maturity schedule
- Ensure that all net mensuration equipment is functional for future surveys
- Investigate the use of bottom contact sensors in commercial fisheries
- Begin the survey in late August or early September to avoid poor fall weather
- Compare preliminary biomass estimates with alternative estimation methods

ACKNOWLEDGEMENTS

We would like to thank Brian Mose, Brian Dickens, Rowan Haigh, and Carl Schwarz for their important contributions to the survey design. Chris Roberts, Kelly Anderson and crew aboard the *F/V Viking Storm* ensured successful completion of the survey with minimal difficulty. The endless energy of Dale Pahti and Dean Gaidica sampled thousands of fish while ensuring the deck crew remained organized. Mark Wilkins and Bob Lauth of NMFS loaned two bottom contact sensing devices that provided our primary information on tow performance. We gratefully acknowledge their assistance and useful advice on survey design and implementation. Scott Buchanan's co-ordination of AMR staff and rapid transfer of field data into a usable database for analysis were invaluable. Jon Schnute's guidance and review were also appreciated to organize the document.

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Table 1. Total estimated areas (km^2) and relative percentages for the six regional strata and three depth zone strata. Trawlable area is the area remaining after the exclusion of untrawlable areas identified in Fig. 2 by Chris Roberts (skipper of the *F/V Viking Storm*).

Region	Name	Depth Zone (m)	Total (km^2)	% of Total Area	Trawlable (km^2)	% of Total Trawlable Area	% of Area Excluded
A	Barkley	501-800	487	6.3	384	5.8	21.1
		801-1200	702	9.1	637	9.7	9.3
		1201-1600	577	7.5	577	8.8	0
B	Loudon/Clayoquot	501-800	330	4.3	233	3.5	29.4
		801-1200	373	4.8	336	5.1	9.9
		1201-1600	694	9.0	694	10.6	0
C	Clayoquot/Estevan	501-800	265	3.4	238	3.6	10.2
		801-1200	380	4.9	380	5.8	0
		1201-1600	462	6.0	462	7.0	0
D	Nootka/500 Line	501-800	274	3.5	154	2.3	43.8
		801-1200	386	5.0	221	3.4	42.7
		1201-1600	448	5.8	427	6.5	4.7
E	Esperanza/Kyuquot	501-800	427	5.5	324	4.9	24.1
		801-1200	355	4.6	290	4.4	18.3
		1201-1600	259	3.4	252	3.8	2.7
F	Cape Cook/Winter Harbour	501-800	201	2.6	79	1.2	60.7
		801-1200	540	7.0	367	5.6	32.0
		1201-1600	571	7.4	523	8.0	8.4
	Total		**7,731**		**6,578**		**14.9**

Table 2. Biological sampling targets by species.

Species	Length/sex/maturity sample (every tow)	Otolith sampling	Target number of otoliths	Random age sample
Longspine thornyheads	Yes	Length stratified	1000	1-2 tows
Shortspine thornyheads	Yes	Length stratified	500	1-2 tows
Shortraker rockfish	Yes	Length stratified	200	No
Rougheye rockfish	Yes	Length stratified	200	No
Dover sole	Yes	Length stratified	500	1-2 tows
Deepwater sole	Yes	Length stratified	200	No
Turbot	Yes	Length stratified	200	No
Sablefish	Yes	Every fish	200	No
Roughscale rattail	Yes	No	N/A	No
Pectoral rattail	Yes	No	N/A	No

Table 3. Basic information associated with each valid survey tow. Traditional tow duration (h) is measured from time of winch lockup to start of retrieval. The SEQ number is the order in which the set was taken on the list of random tow locations. See Appendix E for additional tow details.

Tow #	Region	Depth Zone (m)	Tow Date	Tow Duration (h:min)	SEQ number	Distance travelled (km)	Average speed (km/h)	Tow Depth (m)	
								Start	End
1	A	500-800	15-Sep-01	0:58	1	4.12	4.26	735	763
7	A	500-800	16-Sep-01	1:10	4	5.28	4.52	583	770
8	A	500-800	16-Sep-01	1:00	3	4.32	4.32	701	740
9	A	500-800	16-Sep-01	1:00	7	4.48	4.48	517	588
2	A	801-1200	15-Sep-01	1:00	6	3.60	3.60	1168	1155
4	A	801-1200	15-Sep-01	1:00	1	4.29	4.29	1099	1091
6	A	801-1200	16-Sep-01	1:10	9	5.00	4.29	981	1073
11	A	801-1200	17-Sep-01	1:10	8	4.91	4.21	1140	1130
5	A	1201-1600	16-Sep-01	1:06	1	4.62	4.20	1268	1424
10	A	1201-1600	17-Sep-01	1:22	4	5.54	4.06	1570	1420
12	B	500-800	17-Sep-01	1:00	6	4.23	4.23	625	650
13	B	500-800	17-Sep-01	1:00	5	3.98	3.98	750	647
18	B	500-800	19-Sep-01	1:00	3	4.27	4.27	600	735
19	B	500-800	19-Sep-01	1:00	2	4.26	4.26	780	679
16	B	801-1200	18-Sep-01	1:10	4	4.91	4.21	1024	958
17	B	801-1200	18-Sep-01	1:00	3	4.29	4.29	983	1000
20	B	801-1200	19-Sep-01	1:28	2	5.58	3.81	1100	1030
23	B	801-1200	20-Sep-01	1:00	6	4.01	4.01	869	1059
14	B	1201-1600	18-Sep-01	1:20	2	5.65	4.24	1310	1327
15	B	1201-1600	18-Sep-01	1:20	3	5.56	4.17	1411	1400
21	C	500-800	19-Sep-01	1:00	3	4.33	4.33	607	506
27	C	500-800	21-Sep-01	1:10	5	4.96	4.25	664	651
31	C	500-800	21-Sep-01	1:00	1	4.01	4.01	700	684
32	C	500-800	21-Sep-01	1:10	7	5.19	4.44	702	702
25	C	801-1200	20-Sep-01	1:10	2	5.00	4.28	1130	974
26	C	801-1200	20-Sep-01	1:10	3	4.78	4.10	984	1141
29	C	801-1200	21-Sep-01	1:10	1	4.91	4.21	997	1002
30	C	801-1200	21-Sep-01	1:10	5	4.82	4.13	1062	1038
24	C	1201-1600	20-Sep-01	1:06	2	4.33	3.93	1422	1560
28	C	1201-1600	21-Sep-01	1:26	4	6.01	4.19	1451	1325
37	D	500-800	22-Sep-01	1:10	7	5.07	4.34	641	656
40	D	500-800	23-Sep-01	1:06	2	4.70	4.28	720	800
41	D	500-800	23-Sep-01	1:10	4	4.72	4.04	712	761
43	D	500-800	23-Sep-01	1:21	5	5.54	4.10	633	756
35	D	801-1200	22-Sep-01	1:10	2	4.51	3.86	1200	994
38	D	801-1200	22-Sep-01	1:10	4	4.78	4.10	1180	1056
39	D	801-1200	23-Sep-01	1:10	8	4.78	4.10	820	1051
45	D	801-1200	24-Sep-01	1:30	10	6.08	4.05	938	1350
33	D	1201-1600	22-Sep-01	1:21	1	5.63	4.17	1479	1433
34	D	1201-1600	22-Sep-01	1:10	4	4.87	4.18	1415	1450

Table 3. Basic tow information (cont'd).

Tow #	Region	Depth Zone (m)	Tow Date	Tow Duration (h:min)	SEQ number	Distance travelled (km)	Average speed (km/h)	Tow Depth (m)	
								Start	End
46	E	500-800	25-Sep-01	1:16	2	5.22	4.12	591	525
47	E	500-800	25-Sep-01	0:56	4	3.80	4.07	708	644
52	E	500-800	26-Sep-01	0:57	1	3.84	4.04	645	640
53	E	500-800	26-Sep-01	1:10	7	4.68	4.01	533	592
48	E	801-1200	25-Sep-01	1:11	7	5.01	4.23	910	969
49	E	801-1200	25-Sep-01	1:20	3	5.37	4.03	887	970
50	E	801-1200	25-Sep-01	0:56	1	3.83	4.11	887	1089
51	E	801-1200	26-Sep-01	1:07	6	4.62	4.14	1075	1150
54	E	1201-1600	26-Sep-01	0:59	17	4.04	4.11	1345	1310
55	E	1201-1600	26-Sep-01	0:57	18	3.87	4.07	1345	1242
60	F	500-800	01-Oct-01	1:00	14	4.17	4.17	756	580
61	F	500-800	02-Oct-01	1:03	7	4.47	4.26	710	600
62	F	500-800	02-Oct-01	1:05	15	4.72	4.36	730	700
63	F	500-800	02-Oct-01	1:08	12	4.67	4.12	715	505
56	F	801-1200	28-Sep-01	1:00	5	4.14	4.14	1050	946
57	F	801-1200	28-Sep-01	1:08	7	4.62	4.07	1069	933
58	F	801-1200	28-Sep-01	1:04	4	4.41	4.13	1084	.1068
59	F	801-1200	28-Sep-01	1:10	1	4.82	4.13	1104	1097

Table 4. Tows deemed invalid during the course of the survey and the reason for excluding each tow. Some of these tows were not assigned to a depth zone stratum.

Tow	Region	Depth Zone	Tow Date	Reason for excluding tow
3	A	.	15-Sep-01	Tow aborted early: towed across tide
22	C	500-800	19-Sep-01	Poor door spread and selected out of the random sequence order
36	D	.	22-Sep-01	Very poor bottom contact performance (about 11 minutes of 60)
42	D	.	23-Sep-01	Missed specified random tow location
44	D	801-1200	23-Sep-01	Missed specified random tow location

Table 5. Summary of the number of random tow sequences not selected during the survey by region and depth zone stratum. The category "did not meet criteria" includes tows outside the specified depth or regional strata.

Region	Name	Depth Zone (m)	Rejected random tow sequences			
			Total	Did not meet criteria	Overlap with another tow	Bad bottom terrain
A	Barkley	501-800	3	3	0	0
		801-1200	5	2	0	3
		1201-1600	2	2	0	0
B	Loudon/Clayoquot	501-800	2	2	0	0
		801-1200	2	0	1	1
		1201-1600	1	0	0	1
C	Clayoquot/Estevan	501-800	3	1	2	0
		801-1200	1	0	0	1
		1201-1600	2	0	0	2
D	Nootka/500 Line	501-800	3	2	1	0
		801-1200	6	0	0	6
		1201-1600	2	2	0	0
E	Esperanza/Kyuquot	501-800	3	1	0	2
		801-1200	3	1	2	0
		1201-1600	16	8	0	8
F	Cape Cook/Winter Harbour	501-800	11	1	1	9
		801-1200	3	2	0	1
	Total rejected tows		**68**	**27**	**7**	**34**

Table 6. Total catch by weight (kg) for every species/group taken in 58 valid tows. Number of valid survey tows (from a total of 58) with an occurrence of the indicated species is shown, along with the percentages of valid tows and catch by species.

Species	Scientific Name	Species Code	Valid Catch	Valid Tows	% of Tows	% of Catch
Sablefish	*Anoplopoma fimbria*	455	4,601.5	56	96.6	24.5
Roughscale rattail	*Coryphaenoides acrolepis*	251	3,465.4	55	94.8	18.5
Longspine thornyhead	*Sebastolobus altivelis*	453	3,250.5	58	100.0	17.3
Pectoral rattail	*Albatrossia pectoralis*	256	2,171.1	56	96.6	11.6
Shortspine thornyhead	*Sebastolobus alascanus*	451	1,933.1	58	100.0	10.3
Dover sole	*Microstomus pacificus*	626	1,185.4	45	77.6	6.3
Tanner crabs	*Chionoecetes* sp.	ZAD	465.4	53	91.4	2.5
Pacific flatnose	*Antimora microlepis*	220	394.1	54	93.1	2.1
Longnose skate	*Raja rhina*	059	284.6	21	36.2	1.5
Brittle stars	Ophiurae	5AB	136.0	13	22.4	0.7
Squids	Teuthoidea	92A	122.6	39	67.2	0.7
Deepsea sole	*Embassichthys bathybius*	605	86.3	43	74.1	0.5
Abyssal skate	*Bathyraja abyssicola*	054	80.4	17	29.3	0.4
Twoline eelpout	*Bothrocara brunneum*	235	66.8	36	62.1	0.4
Anemones	Actiniaria	3L0	64.7	41	70.7	0.3
Sandpaper skate	*Bathyraja interrupta*	058	46.8	21	36.2	0.3
Slickheads	Alepocephalidae	642	45.7	30	51.7	0.2
Ophiuroidea (class)	Ophiuroidea	5AA	41.5	7	12.1	0.2
Glass sponges	Hexactinellida	2I0	29.0	7	12.1	0.2
Arrowtooth flounder	*Atheresthes stomias*	602	28.7	6	10.3	0.2
Starfishes	Asteriodea	4GA	27.4	45	77.6	0.2
Sculpins	Cottidae	472	25.3	2	3.5	0.1
Octopuses	Octopoda	97A	24.0	15	25.9	0.1
Shortraker rockfish	*Sebastes borealis*	403	19.1	3	5.2	0.1
Vampire squid	*Vampyroteuthis infernalis*	96F	17.1	11	19.0	0.1
Sponges	Porifera	2A0	16.6	8	13.8	0.1
Brown cat shark	*Apristurus brunneus*	038	15.6	26	44.8	0.1
Pacific sleeper shark	*Somniosus pacificus*	043	14.2	2	3.5	0.1
Giant squid	*Moroteuthis robusta*	96C	11.9	1	1.7	0.1
Filamented rattail	*Coryphaenoides filifer*	254	11.3	12	20.7	0.1
Eelpouts	Zoarcidae	231	10.4	9	15.5	0.1
Scarlet king crab	*Lithodes couesi*	VMD	7.1	7	12.1	0.0
Pacific hake	*Merluccius productus*	225	6.9	4	6.9	0.0
Rougheye rockfish	*Sebastes aleutianus*	394	6.4	3	5.2	0.0
Commander squid	*Berryteuthis magister*	95E	4.5	1	1.7	0.0
Pacific cod	*Gadus macrocephalus*	222	4.0	1	1.7	0.0
Lancetfishes	Alepisauridae	174	3.3	3	5.2	0.0
Deepsea smelts	Bathylagidae	152	2.9	16	27.6	0.0
Jellyfishes	Scyphozoa	3G0	2.4	8	13.8	0.0
Snails and whelks	Gastropoda	10A	2.3	23	39.7	0.0
Nudibranchs	Nudibranchiata	51A	1.9	9	15.5	0.0
Blacktail snailfish	*Careproctus melanurus*	574	1.9	8	13.8	0.0
Northern lampfish	*Stenobrachius leucopsarus*	198	1.6	16	27.6	0.0
Pacific viperfish	*Chauliodus macouni*	171	1.6	16	27.6	0.0
Lumpfishes and snailfishes	Cyclopteridae	568	1.5	7	12.1	0.0
Lumpfishes	Cyclopterinae	569	1.5	1	1.7	0.0
Pacific ocean perch	*Sebastes alutus*	396	1.4	3	5.2	0.0
Sea urchins	Echinacea	6AB	1.4	1	1.7	0.0
Lanternfishes	Myctophidae	185	1.3	13	22.4	0.0

Table 6. Species catch by weight (cont'd).

Species	Scientific Name	Species Code	Valid Catch	Valid Tows	% of Tows	% of Catch
Oregon hair crab	*Paralomis multispina*	VOG	1.1	2	3.5	0.0
Rex sole	*Errex zachirus*	610	1.0	3	5.2	0.0
Aurora rockfish	*Sebastes aurora*	400	1.0	1	1.7	0.0
Ragfish	*Icosteus aenigmaticus*	386	0.9	1	1.7	0.0
Crested ridgehead	*Poromitra crassiceps*	264	0.8	8	13.8	0.0
Poachers	Agonidae	546	0.7	7	12.1	0.0
Longfin dragonfish	*Tactostoma macropus*	167	0.6	6	10.3	0.0
Black eelpout	*Lycodes diapterus*	243	0.6	6	10.3	0.0
Gray sand star	*Luidia foliolata*	4GD	0.6	2	3.5	0.0
Daggertooth	Anotopteridae	176	0.6	1	1.7	0.0
Stout blacksmelt	*Bathylagus milleri*	153	0.5	5	8.6	0.0
Threadfin slickhead	*Talismania bifurcata*	643	0.5	5	8.6	0.0
Highfin dragonfish	*Bathophilus flemingi*	165	0.5	5	8.6	0.0
Dogtooth lampfish	*Ceratoscopelus townsendi*	187	0.5	5	8.6	0.0
Bigfin eelpout	*Lycodes cortezianus*	233	0.4	4	6.9	0.0
Fish eggs	N/A	001	0.3	3	5.2	0.0
Oregon triton	*Fusitriton oregonensis*	28I	0.3	3	5.2	0.0
Basket stars	Euryalae	5QA	0.3	3	5.2	0.0
Red king crab	*Paralithodes camtschaticus*	VNH	0.3	3	5.2	0.0
Prawns	*Pandalus platyceros*	SDF	0.3	3	5.2	0.0
Blackfin poacher	*Bathyagonus nigripinnis*	557	0.2	2	3.5	0.0
Blackmouth slipskin	*Lycodapus fierasfer*	239	0.2	2	3.5	0.0
Spiny tapirfishes	Notacanthidae	092	0.2	2	3.5	0.0
Daggertooth	*Anotopterus pharao*	177	0.2	2	3.5	0.0
Sea anemones	Anthozoa (class)	3J0	0.2	2	3.5	0.0
Octopus species	*Octopus* sp.	98D	0.2	2	3.5	0.0
Blackbelly eelpout	*Lycodes pacificus*	245	0.2	2	3.5	0.0
Sea cucumbers	Holothuroidea	6NA	0.2	2	3.5	0.0
Pacific hagfishes	*Eptatretus stouti*	018	0.2	2	3.5	0.0
Closespine snipe eel	*Avocettina infans*	089	0.1	1	1.7	0.0
Shrimp	Nantantia	SAB	0.1	1	1.7	0.0
Benthoctopus spp	*Benthoctopus* spp.	99A	0.1	1	1.7	0.0
Atelostomata (superorder)	Atelostomata	6KA	0.1	1	1.7	0.0
Flapjack devilfishes	Opisthoteuthidae (family)	97C	0.1	1	1.7	0.0
Torrent sculpin	*Cottus rhotheus*	798	0.1	1	1.7	0.0
Sea cucumber	*Psolus squamatus*	6QD	0.1	1	1.7	0.0
Dwarf wrymouth	*Cryptacanthodes aleutensis*	356	0.1	1	1.7	0.0
Gorgonian corals	Gorgonacea	3S0	0.1	1	1.7	0.0
Inanimate objects	Inanimate object(s)	004	0.1	1	1.7	0.0
Loosejaws	Malacosteidae	168	0.1	1	1.7	0.0
Polychaetes	Polychaeta	0AB	0.1	1	1.7	0.0
Pacific herring	*Clupea pallasi*	096	0.1	1	1.7	0.0
Bigeye flashlightfish	*Protomyctophum thompsoni*	196	0.1	1	1.7	0.0
Spiny dreamer	*Oneirodes thompsoni*	216	0.1	1	1.7	0.0
Smooth dreamer	*Chaenophryne melanorhabdus*	214	0.1	1	1.7	0.0
Bigfin lanternfish	*Symbolophorus californiensis*	200	0.1	1	1.7	0.0
Hermit crabs	Paguridae	VAC	0.1	1	1.7	0.0
Cat sharks	Scyliorhinidae	037	0.1	1	1.7	0.0
Bivalves	Bivalvia	60A	-	-	-	-
Splitnose rockfish	*Sebastes diploproa*	412	-	-	-	-
Total			**18,761.8**			

Table 7. Two alternative biomass estimates (metric tonnes), associated standard errors (SE) and relative errors (RE) for the top 12 species in total aggregate catch in the 2001 survey. One set of estimates is based on CPUE estimates which have been corrected for bottom contact time (Eq. 5 in Appendix D) while the other set used CPUE estimates where the traditional effort component is derived from the winch lockup to retrieval times (Eq. 4 in Appendix D).

	CPUE corrected for bottom contact time			CPUE based on lockup to retrieval time		
Species	Biomass (t)	SE (t)	RE (%)	Biomass (t)	SE (t)	RE (%)
Sablefish	5,873	893	15.2%	3,824	505	13.2%
Roughscale rattail	8,192	1,029	12.6%	6,431	747	11.6%
Longspine thornyhead	4,602	449	9.7%	3,191	302	9.5%
Pectoral rattail	4,882	576	11.8%	4,166	492	11.8%
Shortspine thornyhead	2,246	228	10.2%	1,531	119	7.8%
Dover sole	1,185	172	14.5%	845	112	13.3%
Tanner crab	729	125	17.2%	538	98	18.3%
Pacific flatnose	1,012	95	9.4%	824	100	12.2%
Longnose skate	627	333	53.2%	504	257	51.1%
Squid	158	38	24.2%	112	27	24.0%
Brittle stars	333	282	84.7%	349	313	89.6%
Deepsea sole	140	21	15.2%	104	18	17.6%

Table 8. Summary of biomass estimates (metric tonnes) by depth and regional strata for longspine and shortspine thornyheads. Regions A through F extend from the southeast to northwest as shown in Fig. 2. Estimates for the deep stratum in Region A (Barkley) are derived using an estimated bottom contact time of 60.8 minutes for tow #10.

	Shallow (500-801m)		Intermediate (801-1200m)		Deep (1201-1600m)		All Depth Strata	
Species/Region	Biomass (t)	SE (t)	Biomass (t)	SE (t)	Biomass (t)	SE (t)	Biomass (t)	SE (t)
Longspine thornyhead								
A	244.2	150.8	650.4	135.7	234.5	166.8	**1129.1**	262.6
B	110.5	50.7	635.6	214.4	235.5	93.3	**981.6**	239.2
C	49.1	8.9	497.4	48.2	28.2	0.2	**574.7**	49.0
D	58.8	7.9	403.3	106.0	41.9	0.5	**504.0**	106.3
E & F	255.8	87.9	1105.7	231.3	52.1	3.7	**1413.6**	247.5
All Regions	**718.4**	182.1	**3292.4**	362.6	**592.2**	191.2	**4603.0**	448.5
Shortspine thornyhead								
A	237.5	62.8	157.1	28.6	67.5	21.1	**461.9**	72.2
B	330.0	156.0	128.4	9.9	34.8	31.4	**493.2**	163.3
C	91.1	26.4	101.7	16.7	31.1	20.0	**223.9**	37.1
D	96.2	11.2	69.4	9.0	9.8	9.4	**175.4**	17.2
E & F	572.1	129.5	238.3	40.4	81.3	13.3	**891.7**	247.5
All Regions	**1326.9**	217.1	**694.9**	53.9	**224.4**	45.8	**2246.2**	228.4

Table 9. Summary of biological data collected by species for all samples taken during the 2001 survey, including those samples taken from tows rejected for biomass estimation.

	Number of specimens sampled by Attribute Type					
Species	**Length**	**Otoliths**	**Weight**	**Sex**	**Maturity**	**Genetics**
Sablefish	2,375	187	186	2,375	0	0
Roughscale rattail	2,687	0	226	2,687	0	0
Longspine thornyhead	6,884	1,094	1,094	6,072	5,534	391
Pectoral rattail	1,160	0	114	1,160	0	0
Shortspine thornyhead	2,530	698	507	2,530	2,514	0
Dover sole	1,287	353	350	1,287	1,287	0
Longnose skate	50	0	43	50	0	0
Deepsea sole	200	0	0	200	191	0
Shortraker rockfish	22	22	22	22	22	0
Abyssal skate	29	0	28	29	0	0
Arrowtooth flounder	31	33	31	31	31	0
Sandpaper skate	26	0	26	26	0	0
Pacific ocean perch	16	16	15	16	16	0
Rougheye rockfish	8	8	8	8	8	0
Aurora rockfish	1	1	0	1	1	0
Splitnose rockfish	1	1	1	1	1	0
Total	**17,307**	**2,413**	**2,651**	**16,495**	**9,605**	**391**

Table 10. Sampling frequency by species for the 2001 survey. The target species were designated in the survey design (Table 2).

Species	**Tows with catch but no sampling**	**Tows sampled**	**Total tows with positive catch**	**Otolith sampling target**	**Otoliths collected**
Sablefish	2	54	56	200	187
Roughscale rattail	18	37	55	0	0
Longspine thornyhead	0	58	58	1000	1094
Pectoral rattail	14	42	56	0	0
Shortspine thornyhead	1	57	58	500	698
Dover sole	1	44	45	500	353
Longnose skate	1	20	21	0	0
Deepsea sole	4	39	43	0	0
Shortraker rockfish	1	2	3	200	22
Abyssal skate	2	15	17	0	0
Arrowtooth flounder	3	3	6	200	33
Brown cat shark	26	0	26	0	0
Pacific sleeper shark	2	0	2	0	0
Rougheye rockfish	0	3	3	200	8
Cat sharks	1	0	1	0	0

Table 11. Numbers of specimen lengths available in GFBio for selected species. Values in brackets represent the subsample ratio, otherwise all specimens were measured. For example, 36 (1:4) indicates 36 specimens were measured and every 4th fish was selected for the subsample, therefore a total of 144 specimens were collected during the tow.

Tow	Roughscale rattail	Pectoral rattail	Shortspine thornyhead	Longspine thornyhead	Sablefish	Dover sole
1	31	7	95	214	117	15
2	36 (1:4)	54	12	280	27	2
4	54	15	14	89 (1:7)	16	
5	76 (1:2)	18	3	47	9	
6	45	8	24	125 (1:8)	34	
7	5	2	70 (1:3)	66 (1:2)	217	81
8	30	8	43	80	29	64
9		11	113	39	21	68
10	52	80 (1:3)	21	91 (1:4)		3
11	178	85	11	678 (1:4)	15	
12	12	10	80 (1:2)	75	124	2
13	18	19	46 (1:3)	68 (1:5)	86	34
14	68 (1:5)	41 (1:5)	11	93 (1:4)	6	1
15	112 (1:4)	41 (1:4)	1	65 (1:2)	3	
16	67 (1:4)	37	19	79 (1:12)	44	7
17	25	4	16	259 (1:3)	7	1
18		35	41	65	18	46 (1:3)
19	35	7	72	79 (1:4)	59	96
20	114	140	32	130 (1:15)	53	
21		21	72	86		19
22	7		33	121	40	37
23			24	588 (1:6)	39	61
24	95	26	4	36		5
25	101	31	16	183 (1:4)	38	2
26	123	42	28	195 (1:6)	21	5
27		23	78	172	57	10
28			3	37	2	1
29	111	8	24	103 (1:9)	15	
30	69	41	29	132 (1:13)	39	
31			38	70 (1:3)	27	22
32			36	36 (1:5)	47	56
33	115 (1:6)	54 (1:3)	8	80	1	3
34	68 (1:4)	38 (1:3)	1	39		1
35	58		21	131 (1:16)	53	
36	44		10	63 (1:7)	18	
37			57	92 (1:2)	21	71 (1:2)
38	82 (1:3)	32	7	59 (1:9)	22	3
39			15	64 (1:10)	49	9
40			43	60 (1:3)	118 (1:3)	41
41				50 (1:4)	37	41

Table 11. Number of specimen lengths in GFBio (cont'd).

Tow	Roughscale rattail	Pectoral rattail	Shortspine thornyhead	Longspine thornyhead	Sablefish	Dover sole
42			61	61	146	21
43			61 (1:2)	75 (1:2)	182	21
44			30	49 (1:16)	54	5
45	108 (1:2)		37	75 (1:12)	23	
46			62 (1:2)	65	20	14
47			50	91	4	3
48	70	10	36	128 (1:8)	15	2
49	76 (1:3)	20	63	97 (1:12)	21	8
50			23	83 (1:12)	19	20
51	89 (1:3)	22	17	96 (1:10)	30	2
52	95 (1:2)		83	76 (1:10)	73	42
53			109	61	14	28
54	72 (1:2)	18	11	23	3	1
55	69 (1:2)	35	11	24	2	1
56	64	6	15	103 (1:7)	29	
57		12	25	109 (1:16)	43	
58	96	13	6	97 (1:8)	15	
59	60 (1:5)	52	20	89 (1:7)	5	
60		7	76	130 (1:2)	83	80
61	19	14	233	102 (1:2)	31	110
62	38	9	136	101 (1:2)	21	50
63		4	94 (1:4)	130	13	72

Table 12. Regression coefficients from fitting length-weight data to the model defined by Eq. 7 in Appendix D for the top six species in the 2001 survey. All length-weight pairs were fitted without excluding any outliers.

Species	Exponent	Constant	R^2	N
Sablefish	2.677	8.20E-05	86%	186
Roughscale Rattail	2.827	1.12E-05	88%	226
Longspine Thornyhead	3.019	1.12E-05	91%	1094
Pectoral Rattail	2.810	1.34E-05	75%	114
Shortspine Thornyhead	3.132	5.73E-06	96%	507
Dover Sole	3.118	5.13E-06	93%	349

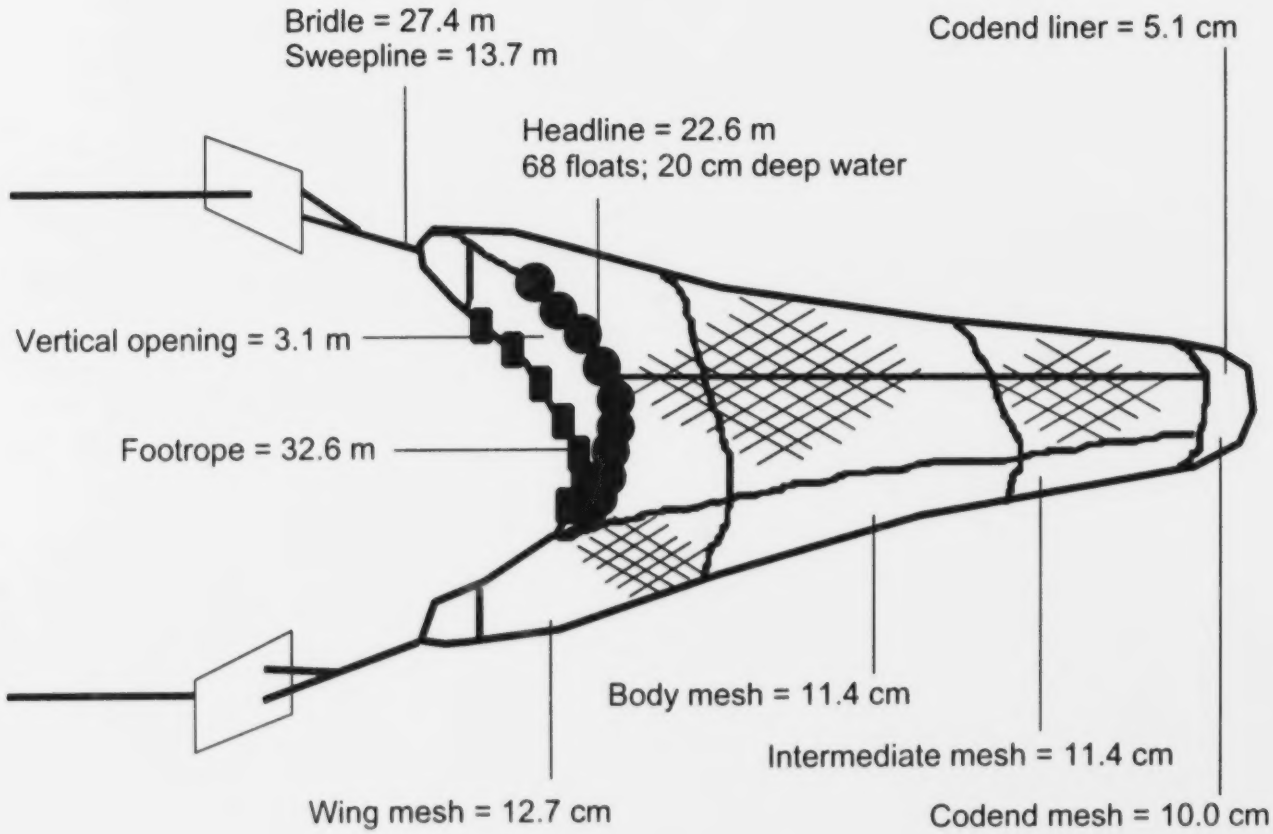
Bridle = 27.4 m
Sweepline = 13.7 m
Codend liner = 5.1 cm
Headline = 22.6 m
68 floats; 20 cm deep water
Vertical opening = 3.1 m
Footrope = 32.6 m
Body mesh = 11.4 cm
Intermediate mesh = 11.4 cm
Wing mesh = 12.7 cm
Codend mesh = 10.0 cm

Figure 1. Atlantic Western II box trawl specifications.

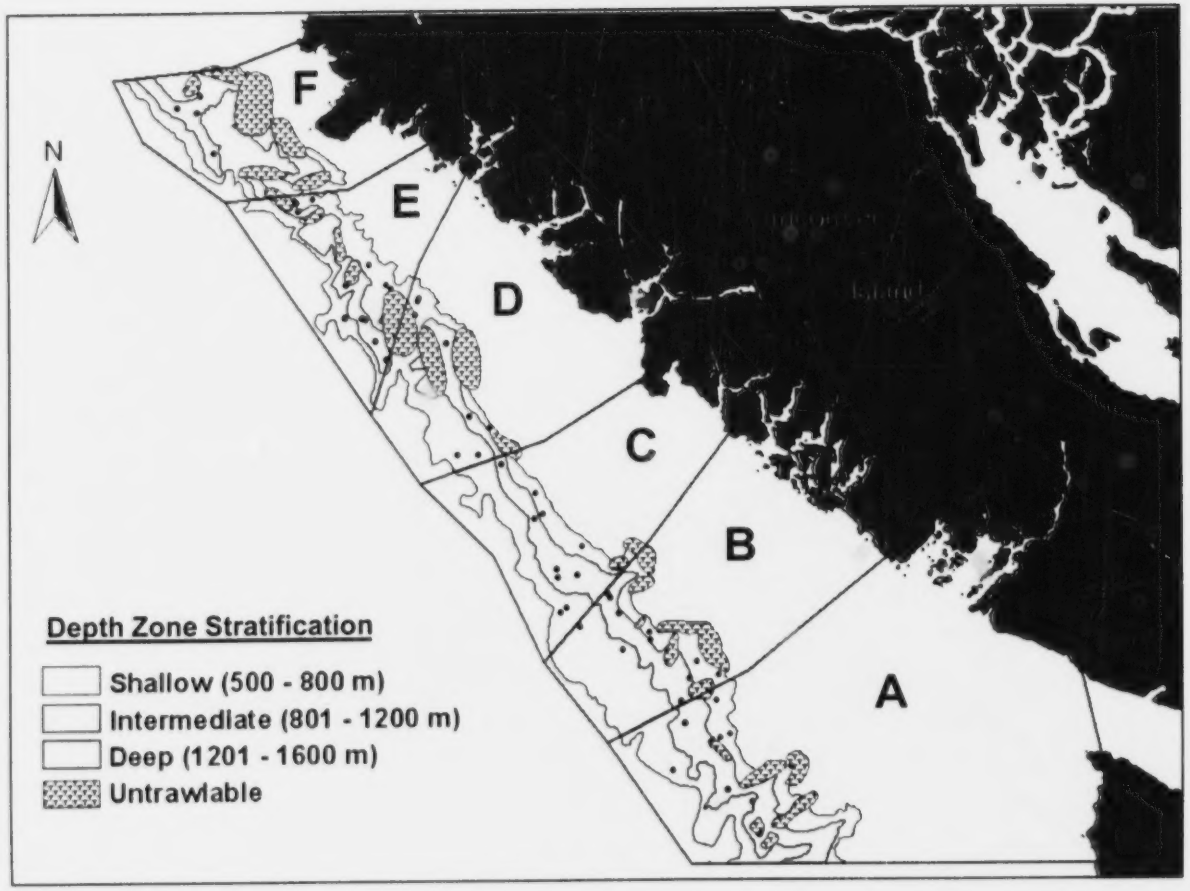

Figure 2. Map of the region and depth zone survey strata (Table 1) with superimposed tow locations (dots) for 58 valid sets. Note that the depth contours shown here are only approximate and excluded untrawlable areas are marked with crosshatches.

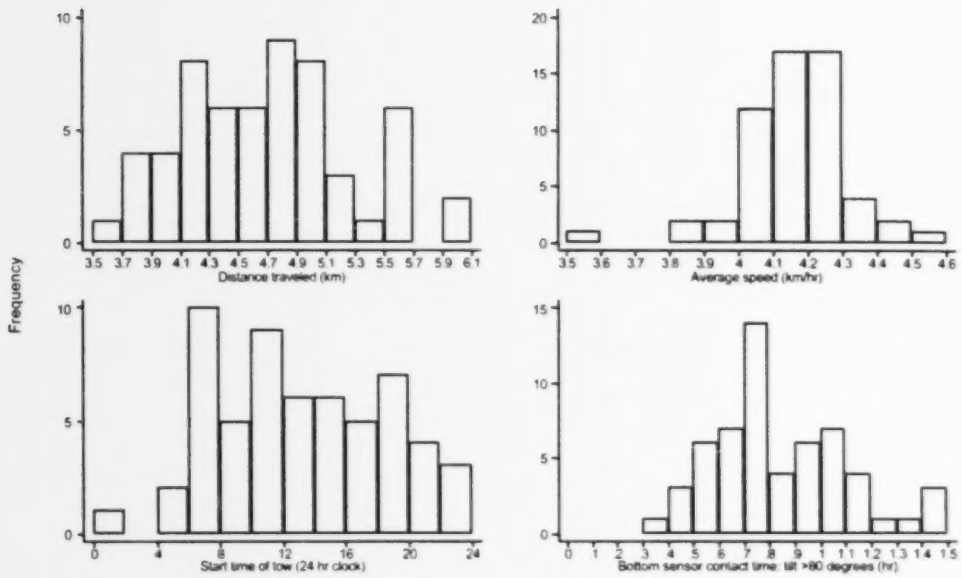
Frequency
Distance traveled (km)
Average speed (km/hr)
Start time of tow (24 hr clock)
Bottom sensor contact time: tilt >80 degrees (hr)

Figure 3. Frequency distribution of four variables associated with each valid survey set: distance travelled (km), average speed (km/h), the start time of the tow (24 h clock), and the amount of time in contact with the bottom (defined as bottom contact sensor tilt angle > 80°).

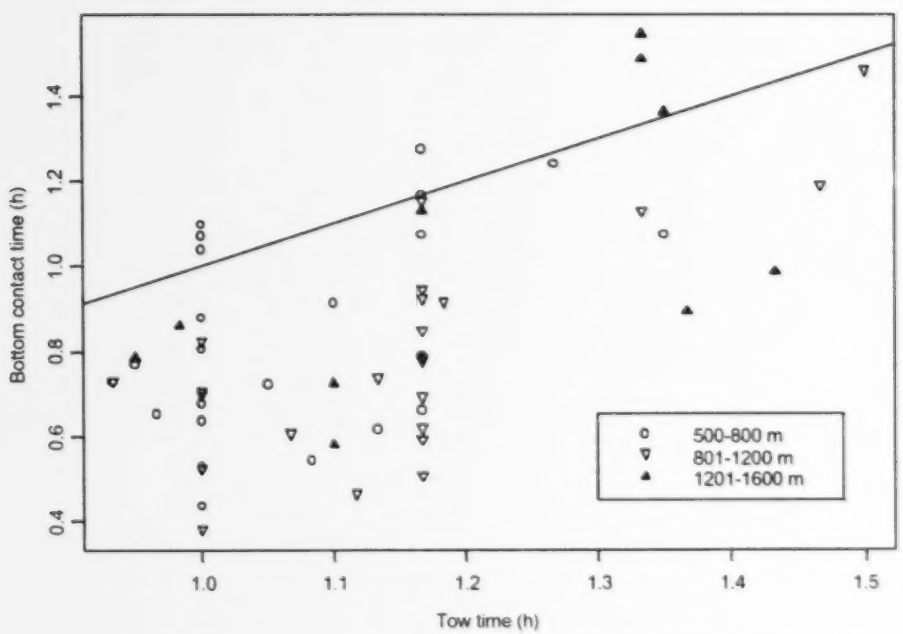

Figure 4. Distribution of bottom contact time versus tow time. The reference line represents a 1:1 ratio.

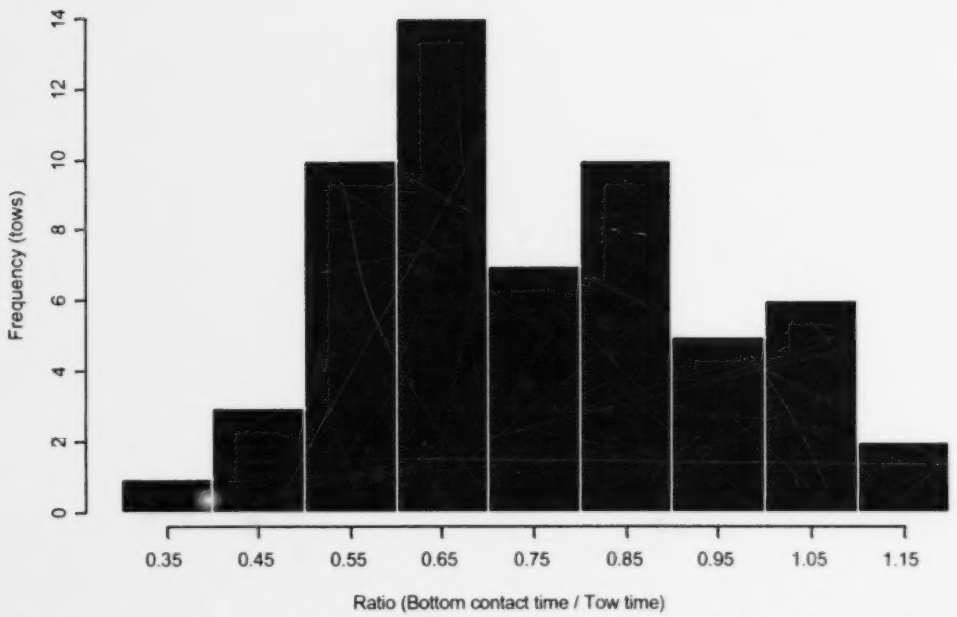

Figure 5. Distribution of the ratio of bottom contact time (total time where tilt angle >80°) to traditional tow time (from winch lockup to winch release).

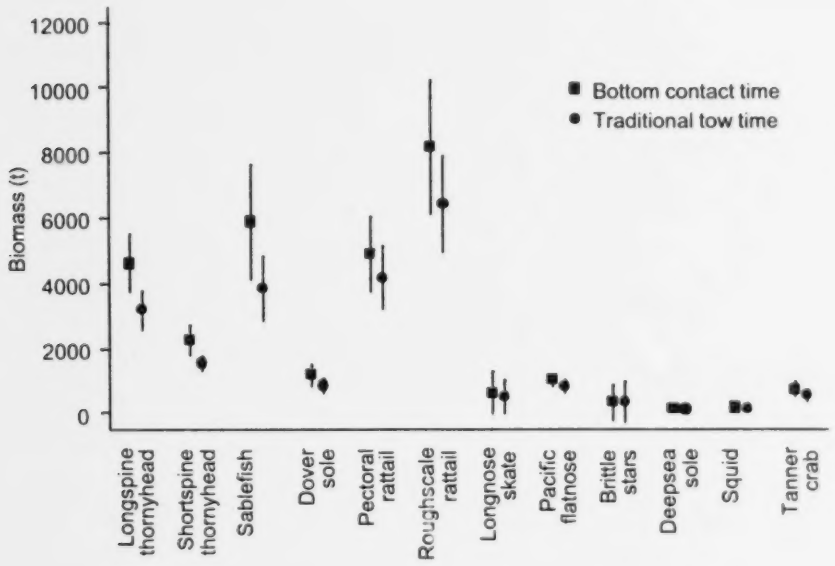

Figure 6. Biomass estimates and confidence bounds (±[2*SE]) for the top 12 species by total aggregate catch in the 2001 survey based on CPUE estimates which have been corrected for bottom contact time compared with biomass estimates based on CPUE estimates calculated from winch lockup to retrieval time.

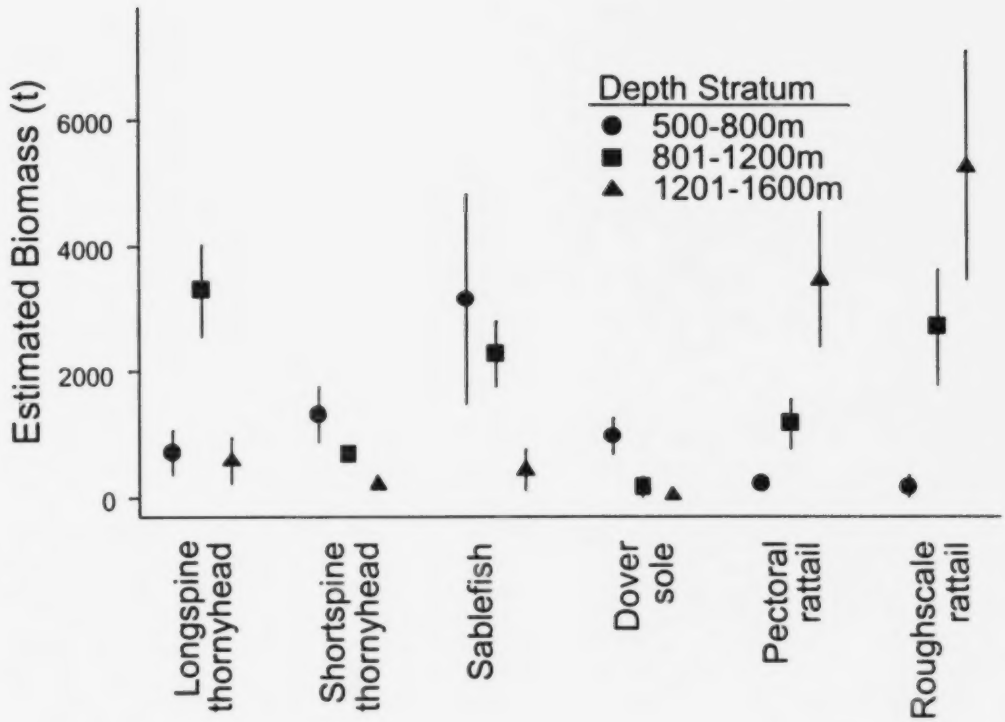

Figure. 7. Distribution of estimated biomass and confidence bounds (±[2*SE]) among the three depth strata. Biomass is based on bottom contact times for valid tows only. See Table 8 for the standard errors associated with the thornyhead estimates.

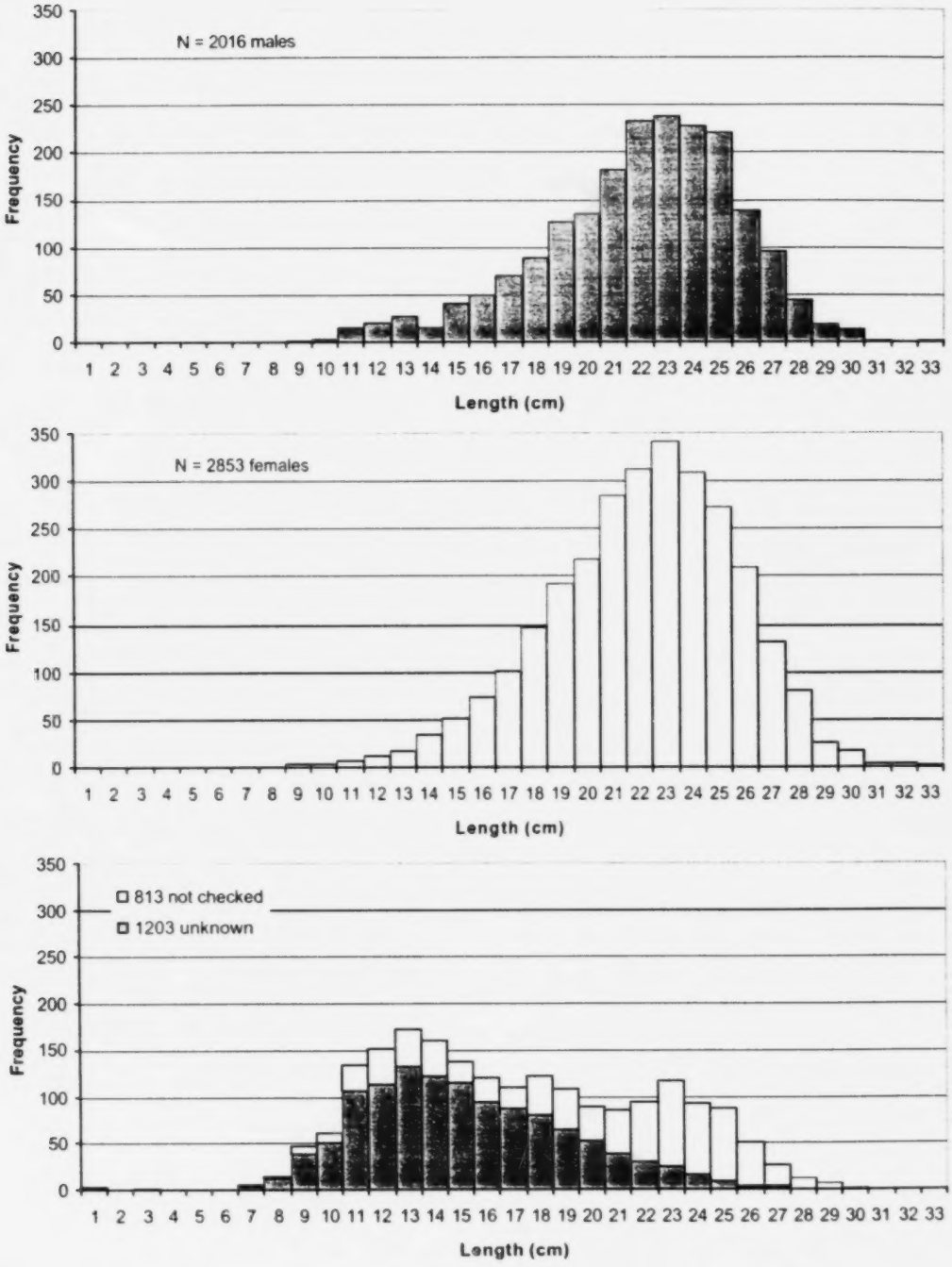

Figure 8. Length frequency histograms from the raw data for male and female longspine thornyheads, and the proportion of each length interval assigned to sex codes. Unknown sex indicates that the specimen was inspected but sex could not be determined.

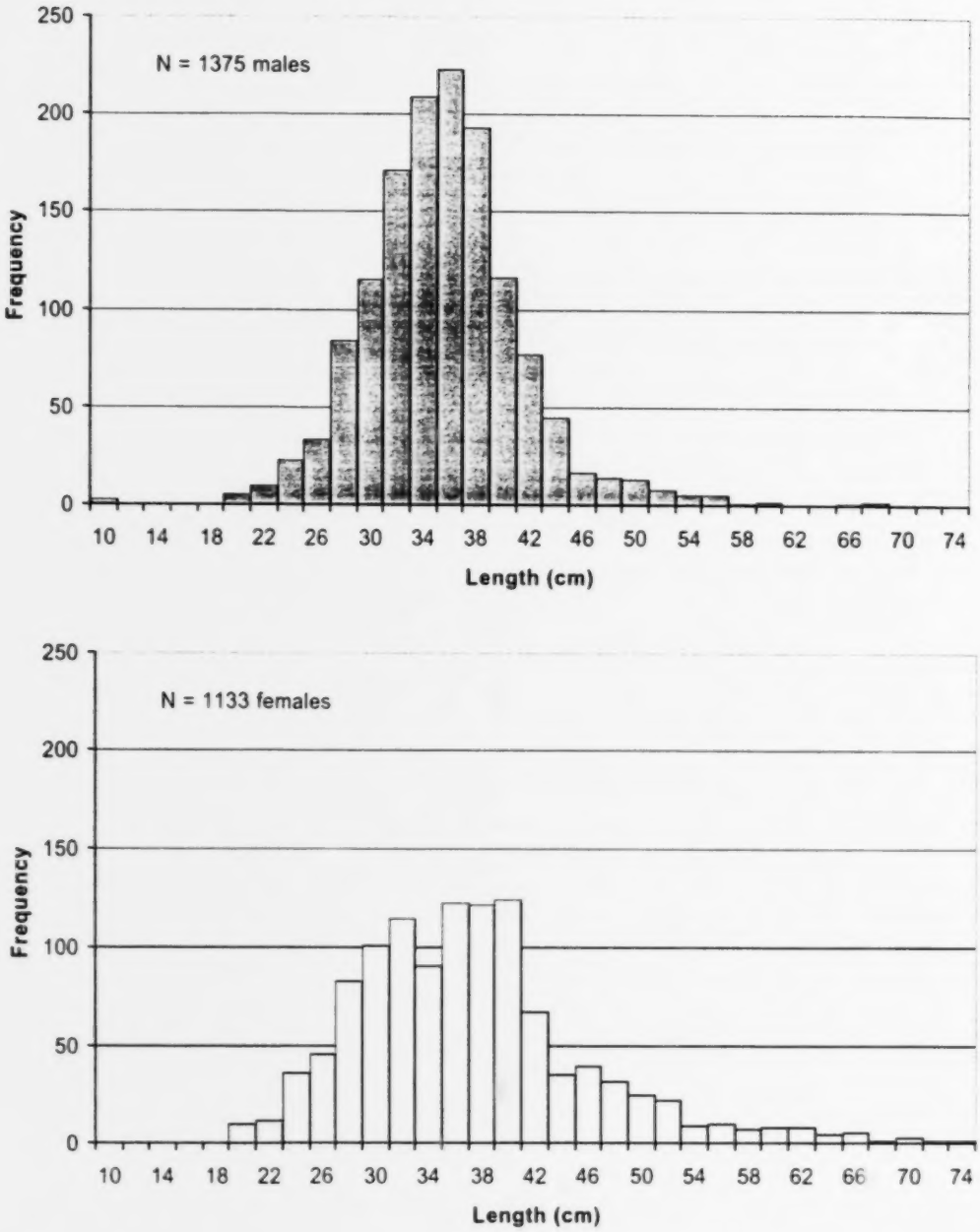

Figure 9. Length frequency histograms from raw data for male and female shortspine thornyheads from all 63 tows. Values are not weighted by region or depth stratification.

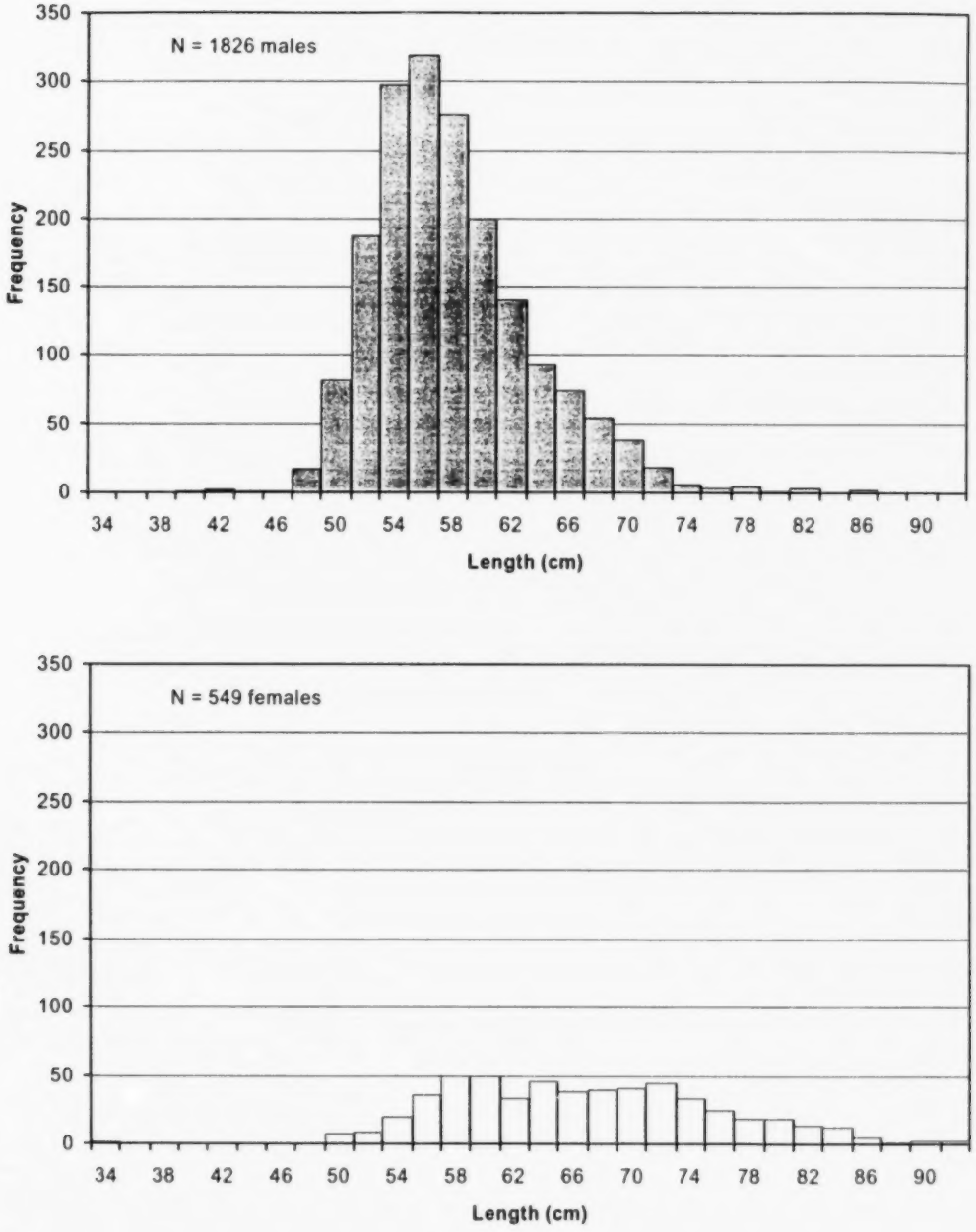

Figure 10. Length frequency histograms from the raw data for male and female sablefish from all 63 tows. Values have not been weighted by region or depth stratification.

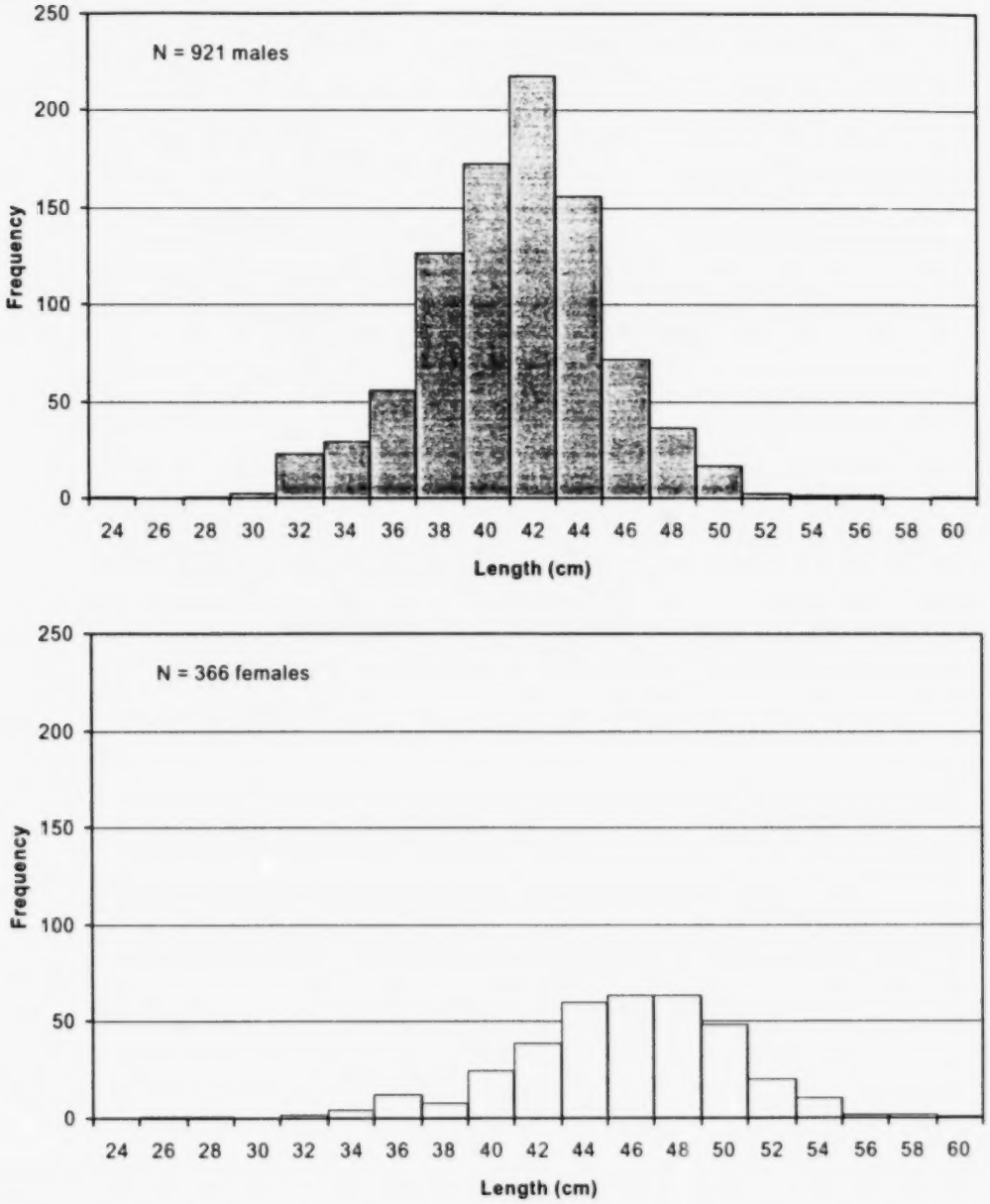

Figure 11. Length frequency histograms for male and female Dover sole based on raw data from all 63 tows. Values are not weighted by region or depth stratification.

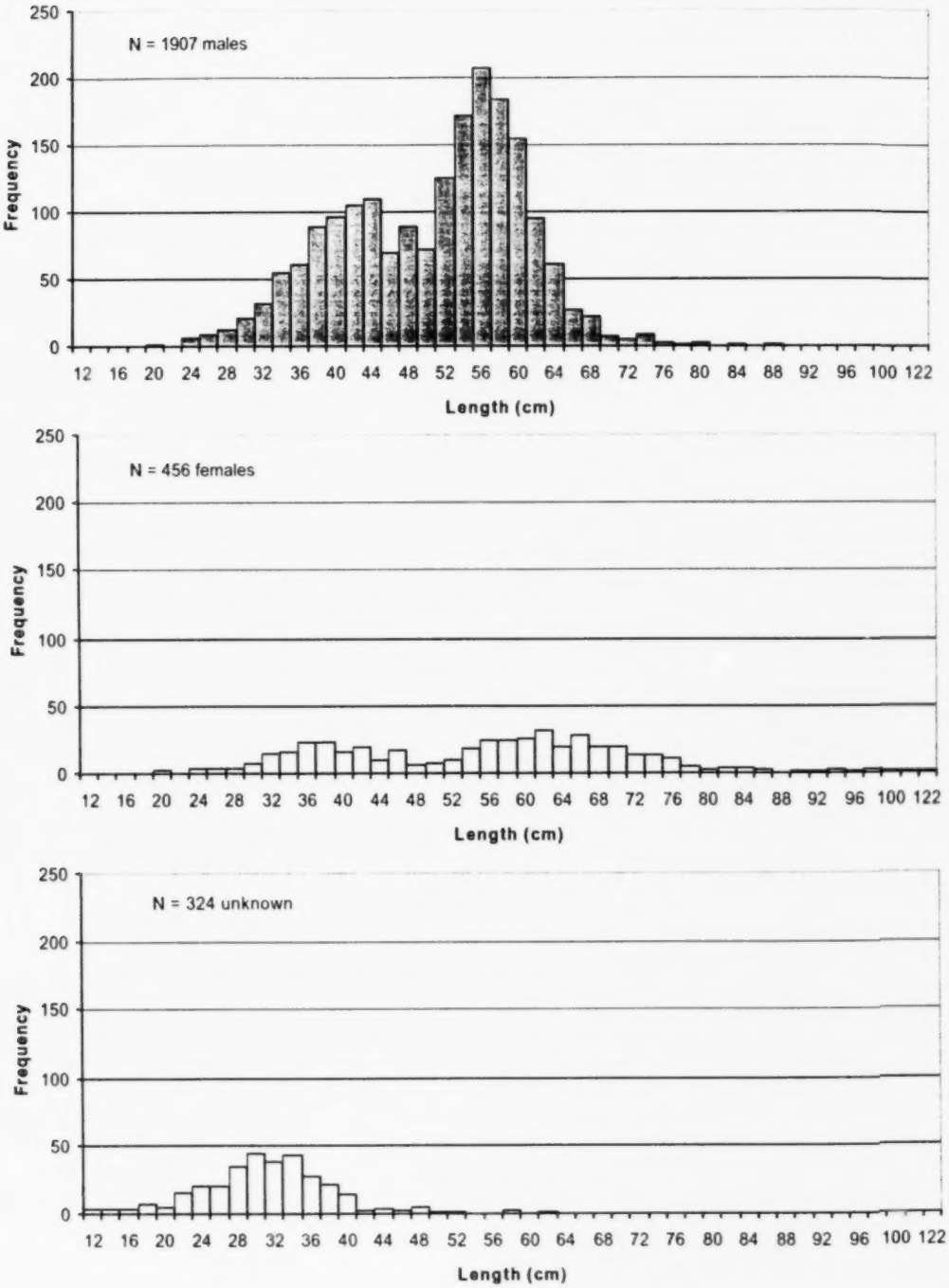

Figure 12. Length frequency histograms from raw data for male, female and unsexed roughscale rattails from 63 tows. Values have not been weighted by region or depth stratification.

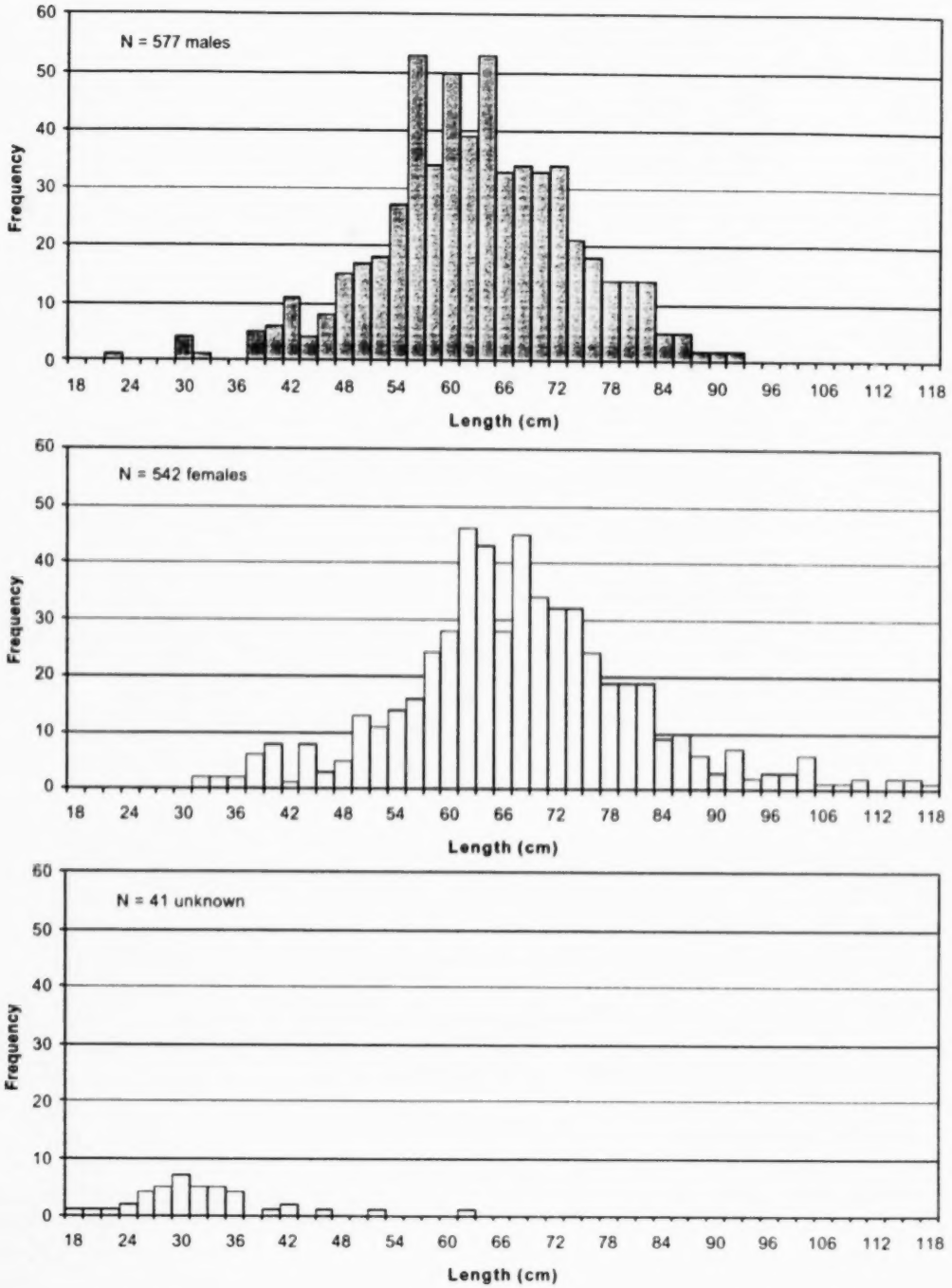

Figure 13. Length frequency histograms from raw data for pectoral rattails from all 63 tows. A small number of specimens could not be sexed. Values are not weighted by region or depth stratification.

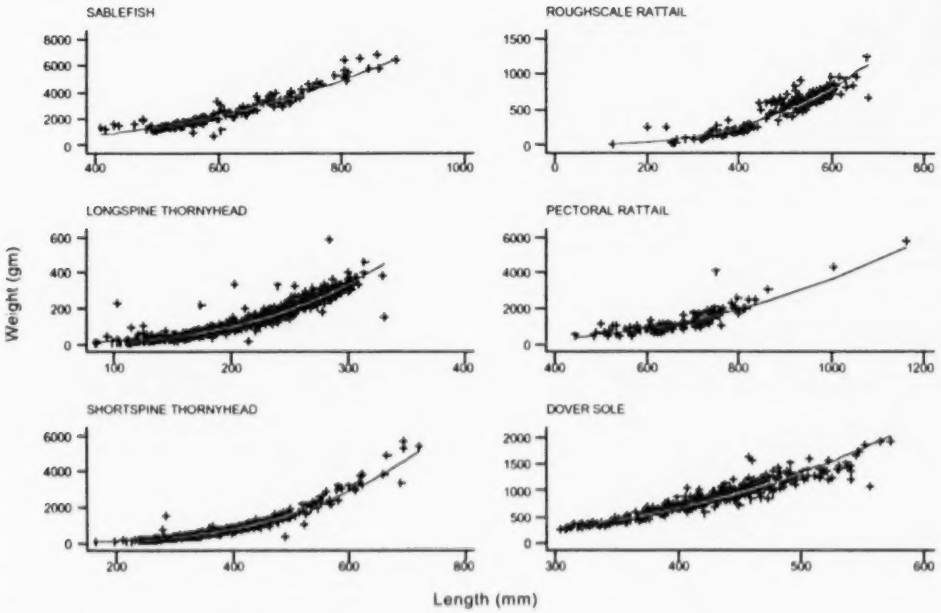

Figure 14. Fitted length-weight regressions for the top six species in the 2001 survey. All length-weight pairs were fitted without excluding any outliers.

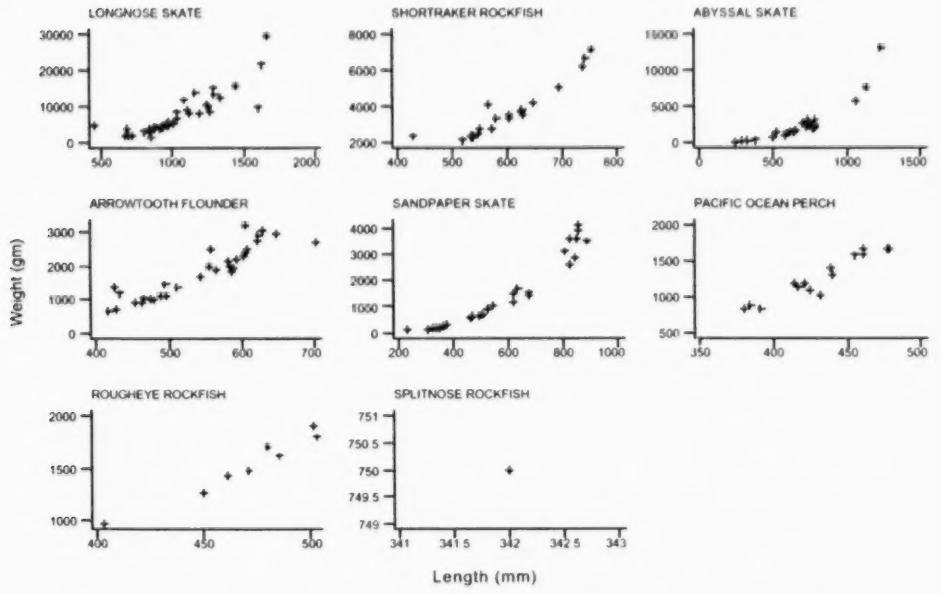

Figure 15. Remaining length-weight data collected by the 2001 survey plotted by species.

APPENDIX A: SURVEY DESIGN AND SAMPLING PROTOCOLS

A1. INTRODUCTION

The survey design incorporated in this document is based on a series of discussions and shared documents over a period of nearly eight months between scientists from the Pacific Biological Station, Simon Fraser University, the CGRCS, and the U.S. National Marine Fisheries Service. There has also been considerable discussion with DFO management and with representatives of the fishing industry, primarily those affiliated with the CGRCS. The survey was tendered in early August 2001, the bids were evaluated in mid-August, and the survey contract was awarded on 27 August to the Viking Storm skippered by Chris Roberts and Kelly Anderson.

The final design is for a survey that will target the longspine thornyhead resource. This is reflected in the depth range chosen for the survey and the survey coverage that is restricted to the west coast of Vancouver Island. The reasons for this decision are:

a. all parties recognise that the developing thornyhead fishery requires robust fisheries data which can be incorporated into future stock assessments;

b. thornyheads appear to be distributed relatively uniformly on the bottom compared to other slope/shelf rockfish species, which should result in a manageable CV from the initial survey;

c. all parties have agreed that the first survey will be a learning experience and that it would be initially advantageous to limit the scope of the survey to a potentially achievable goal.

These considerations have led to the design that follows in this memo. While this design is largely finalized, aspects of the design are still being settled and may be changed from what is presented here.

A2. OBJECTIVES OF THE SURVEY

1. To estimate the relative abundance of longspine thornyhead lying between a southern boundary defined by the Canada-U.S. border and a northern boundary defined by Lawn Point immediately south of Quatsino Sound (approx. 50° 17' N) between the depths 500 m and 1 600 m. The target relative error of the biomass estimate is 20% $(RE = \mu/SE)$ (where μ is the mean catch rate for the survey and SE is the standard error of the survey catch rate).
2. To estimate the distribution by size class and sex category of the longspine thornyhead population within the extent of the survey area, given the uncertainty that results from sampling with non-representative fishing gear.
3. To obtain quantitative biological information pertaining to selected finfish and invertebrate species.

Appendix A (cont'd)

Figure A1. Map of the original 12 thornyhead fishing grounds suggested by Brian Mose (December 2000) superimposed with most of the relevant tows in the PacHarvest database (over period 15 February 1996 to about 31 July 2000).

A3. ELEMENTS OF THIS DESIGN

- The survey will be targeted at the vulnerable slope and shelf rockfish species between the depths of 500 and 1600 m. It will be conducted on the west coast of Vancouver and will be based on the 12 sub-areas proposed by Brian Mose in December 2000 (Figure A1) which largely reflect the natural boundaries of the existing longspine thornyhead fishery. Although the analyses based on the available catch and effort data did not reveal measurable latitudinal differences for either of the thornyhead species, the use of these strata will ensure good geographical coverage.
- The number of tows allocated to each areal stratum is designed to ensure that a reasonably high level of precision for longspine thornyheads is achieved over the entire survey area, based on an analysis of the existing catch and effort data for longspines. This design requires 10 tows per areal stratum, 4 tows in each of the two shallower strata and 2 tows in the deepest stratum. Given this design for 12 areal strata, a total of 120 tows would be required for the survey. However, it was felt that this number of tows would be difficult to achieve given that the survey would not be undertaken until September with an accompanying onset of deteriorating weather, it was decided to halve the number of tows

Appendix A (cont'd)

in the survey by combining adjacent areas while keeping the same underlying design for each of the combined areal strata (Figure A2).

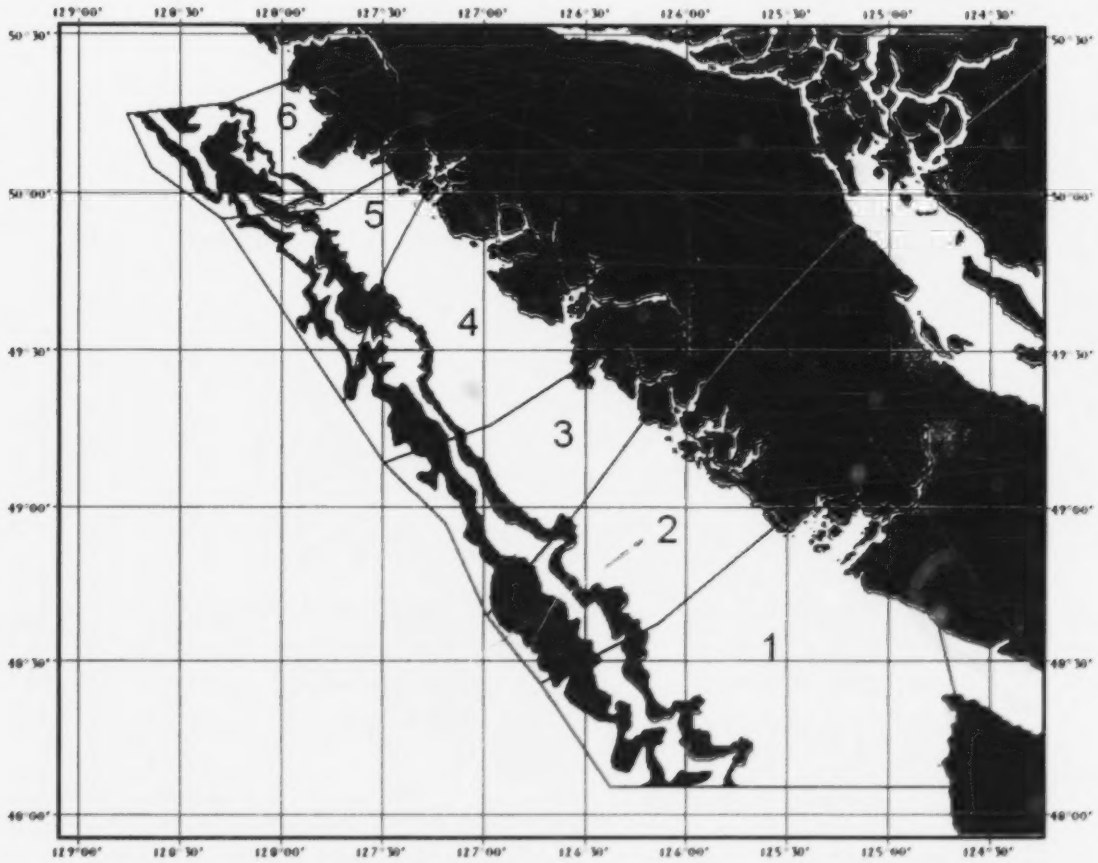

Figure A2. Map of the 6 areal strata and the 3 depth zones to be used in the September 2001 west coast Vancouver Island survey. These strata were obtained by combining adjacent strata plotted in Figure A1. Stratum names are listed in Table A2.

- This new areal stratification will still ensure that the goal of covering the entire area will be achieved. As well, the lack of observable latitudinal effects in the analyses presented in the PSARC paper (Starr & Schwartz 2000; see also the Appendix attached to this design) means that there was no observable structure in the variation between tows in the available data. Therefore, the number of areal strata chosen is somewhat arbitrary and is dictated by the design RE for the survey.
- The following table defines the depth strata selected for this design and the time to be towed in each depth stratum. The tow time in the shallowest stratum (501-800 m) has been set to 1 hour to ensure that large catches of some slope rockfish species are minimised.

Appendix A (cont'd)

These tow times should be considered to be the maximum tow time and some tows may be shorter, depending on bottom conditions or other considerations.

Depth Stratum	Number of assigned tows	Length of tow in stratum[1]
501 – 800 m	4	1 hour
801 – 1200 m	4	2 hours
1201 – 1600 m	2	2 hours

[1] Defined as the number of hours between the time the net is first in contact with the bottom and the beginning of the haul.

A4. SUGGESTIONS FROM SCIENTISTS FROM THE NORTHWEST FISHERIES SCIENCE CENTER

Bob Lauth and Mark Wilkins from the Northwest Fisheries Science Center (National Marine Fisheries Service, NOAA Fisheries) kindly discussed the overall design of this survey in the light of their extensive experience in conducting bottom trawl surveys on the west coast of the continental U.S. and in the Gulf of Alaska.

- Because of the steep and uncertain bottom terrain, they indicated that the expectation of successfully completing useable research tows that were longer than 0.5 h was low. Therefore, the actual time towing should range from 0.5 h to the indicated maximum in the above table. The length of time towed for any research tow will be dictated by the current conditions of the bottom, the weather and the expected size of the catch.
- They also indicated that long tows tended to capture quantities of fish which were too large to completely enumerate and which would likely require sub-sampling of the catch. They considered this to be unsatisfactory, as fish tend to stratify in the net codend, leading to possible bias. On the other hand, there is some evidence in the commercial catch and effort data that longer tows (greater than 3 hours in length) had noticeably lower RE for longspine thornyhead compared to shorter tows (Starr & Schwarz 2000). Therefore, there is a potential design conflict in this survey between the possible bias resulting from sub-sampling the catch and the desire to keep the survey variability as low as possible by having longer tow periods.
- The rugged nature of the undersea terrain may also result in losing or badly damaging the survey net. They indicated that they routinely carry up to five spare nets so that the survey will not be compromised in the event of losing or severely damaging a net. It is likely that this survey as well should carry several spare nets if that is economical feasible.
- They indicated that it may be very difficult to successfully sample in the deepest stratum (1 201-1 600 m). This could result from the difficulty of finding suitable locations to tow and the limitations of the available gear. They also thought that the longspine resource was not found in any abundance lower than about 1 300 m. Although they did not recommend abandoning this aspect of the survey, they suggested that we adopt a flexible attitude,

Appendix A (cont'd)

viewing the samples in this depth stratum as investigative and experimental which may require modification while the survey is being conducted.

- They noted that the current design does not specify the type of ground gear to be used on the net. The "roller" gear that is routinely used by Canadian longspine draggers apparently lifts the net off the bottom somewhat and may lower the catchability of the smaller longspines. The U.S. surveys use "cookies" made of rubber disks, which is considered more effective in capturing smaller fish. However, fishing gear generally captures fish selectively at different sizes and it is probably not possible to modify such gear to be equally selective for all sizes. There is a comparison of the longspine length frequencies from the U.S. "slope" surveys with the commercial length frequencies from the west coast of Vancouver Island (Figure; Starr & Haigh 2000) which shows that the length frequency distributions were similar in two of the three years compared. Therefore, I have concluded that there is no substantial justification to ask the Viking Storm to change away from its current "roller" configuration.

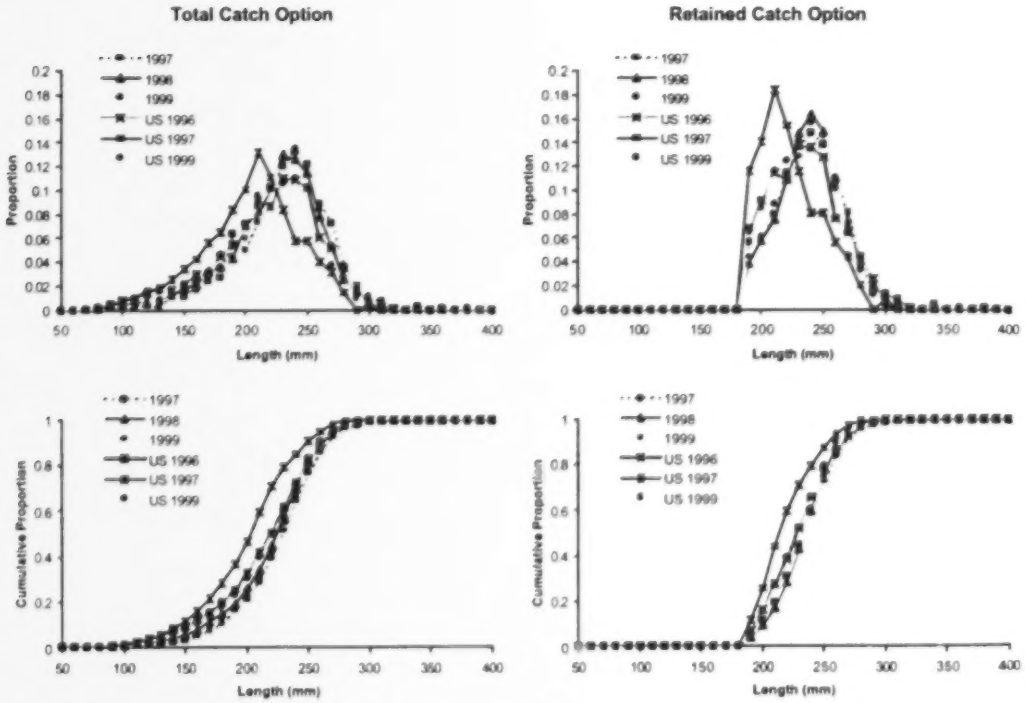

Figure A5. Comparison of length frequency distributions and cumulative length frequency distributions for commercial data from the west coast of Vancouver Island and U.S. NMFS trawl survey data off the coast of Washington. The survey data are presented by year and the commercial data by standardized fishing year under both the "total" and "retained" catch option.

Appendix A (cont'd)

A5. THE SURVEY DESIGN

The GLM analysis presented in the Appendix and in the November PSARC paper (Starr & Schwarz 2000) indicated that there would not be much gain in survey precision for the two thornyhead species from using the proposed areal strata given in Figure A2 and concluded that the main reason for including these strata would be to spread the survey effort over the entire west coast (the analysis is attached as an appendix to this paper). Given the lack of contrast in the apparent population CVs, each stratum is proposed to receive the same number of tows.

The design provided in Table A2 is based on the assumption that tows will be chosen randomly from a prescribed list of locations. If a tow location is not feasible, then another tow will be selected from a list of alternative random tow locations in a specified sequence. The expected relative error (*RE*; see Objective 1, page 1) for each depth stratum, given an assumed underlying population CV based on the analysis of commercial catch and effort data and the number of tows in a stratum (Starr & Schwarz 2000), is presented in Figure A6.

Table A2. Survey design based on equal allocation of tows to each of the 6 areas defined in Figure A2. Approximate relative errors (RE) for the two thornyhead species for the sum of the main depth strata are estimated from information provided in Table A3 and Figure , given an assumed level of underlying population variability based on the analysis of commercial catch and effort data presented in Starr & Schwarz (2000). N/A: not estimable.

Longspine Area	**501-800**	**801-1200**	**1201-1600**	**Total all depths**
Barkley	4	4	2	10
Loudon/Clayoquot	4	4	2	10
Clayoquot/Estevan	4	4	2	10
Nootka/500 Line	4	4	2	10
Esperanza/Kyuquot	4	4	2	10
Cape Cook/Winter Harbour	4	4	2	10
Total	**24**	**24**	**12**	**60**
Approximate Longspine *RE*	**20%** (@100% Pop CV)	**12.5%** (@60% Pop CV)	N/A	
Approximate Shortspine *RE*	**17.5%** (@80% Pop CV)	**17.5%** (@80% Pop CV)	N/A	

Appendix A (cont'd)

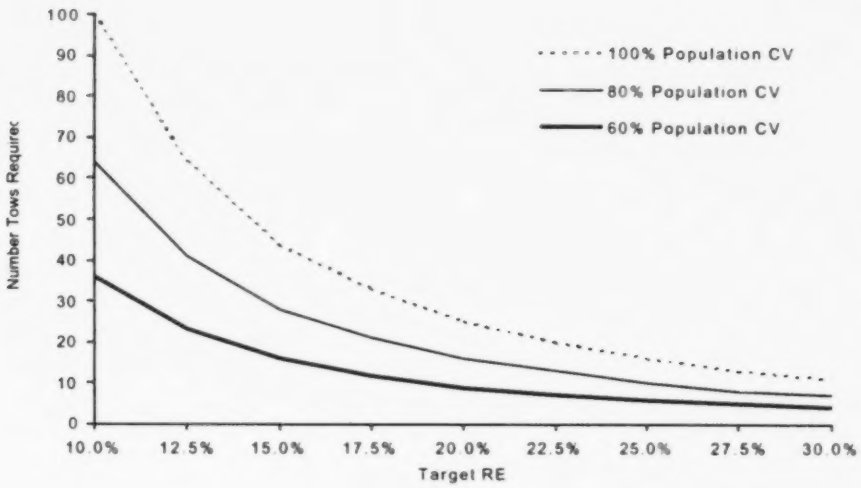

Figure A6. Relationship of the number tows required in a depth stratum as a function of the target RE and the assumed thornyhead population variability, expressed here as a CV. Refer to Starr & Schwarz (2000, Section 8.3) for an explanation on how this figure was derived.

Table A3. Number tows required in each depth stratum as a function of the target relative error (RE) and the underlying population variability.

	Underlying Population CV		
Target RE	**100%**	**80%**	**60%**
10.0%	100	64	36
12.5%	64	41	23
15.0%	44	28	16
17.5%	33	21	12
20.0%	25	16	9
22.5%	20	13	7
25.0%	16	10	6
27.5%	13	8	5
30.0%	11	7	4

Appendix A (cont'd)

A6. PROTOCOL FOR SURVEY GEAR

1. The survey contract is for a tenure of three (3) years, ensuring that the survey will be conducted by the same vessel and gear for those years. The contract specifies that the vessel master is required to be a specialist in the Canadian longspine fishery. The current skippers of the Viking Storm are Chris Roberts and Kelly Anderson.
2. The Viking Storm is to provide two nets (#2 box trawl each built to the same agreed specifications), 32 mm (1 ¼ inch) cod end liner, doors (Thyboron 107), bridles for the net and a pair of suitable main warp cables from the vessel. The length of the warp and the weight of the doors are to be measured accurately prior to the beginning of the survey.
3. Most of the initial gear specifications will be determined by the equipment present on the Viking Storm. The survey contract stipulates that selected net will be sequestered for exclusive use in future surveys. All gear used will be documented for future reference.
4. The survey contract specifies that the net must be restored to its original condition whenever it is mended and that the condition of the net be externally audited at the beginning of each subsequent survey based on a set of written specifications that will be drawn from the original net design.
5. The following net monitoring equipment have been made a condition of the survey contract: a) wingspread monitor or doorspread monitor [not yet determined]; b) pressure depth monitor; c) codend sensor; d) temperature monitor. A "bottom contact sensor" will be loaned to the survey by the U.S. National Marine Fisheries Service (see Appendix 2 for a description of the device). This device will give a complete monitoring of the period of contact with the bottom during each tow.
6. The survey will begin on 10 September and will continue until the 60 tows described in Table A2 are completed. This should take approximately 15 to 20 days to complete.
7. Some gear trials will likely be necessary to properly determine the deployment of the gear and the electronic net monitoring gear.

A7. PROTOCOL FOR SELECTING AND CONDUCTING SURVEY TOWS

8. Tows will be allocated to 6 areal strata using three depth strata as described in Table A2. The depth boundaries will be determined by the mean interpolated depth lines (500 m, 800 m, 1200 m, and 1600 m) based on available bathymetric data (Figure A4). This is to ensure that the strata definitions are continuous. The definitions of these 18 strata are maintained by Rowan Haigh.
9. Each areal/depth sub-stratum will be characterised by a grid of 500 m x 500 m cells (e.g.. Figure A7). There are 30,909 of these grid cells (or about 7,727 km^2) within the survey area (Table A4). A list containing a sequence of randomly selected grid co-ordinates from each of the 18 area/depth sub-strata will be provided to the Viking Storm from which each tow is to be executed until the required number of tows for that sub-stratum is completed. The vessel master is to select a starting location within the selected grid, given that the

Appendix A (cont'd)

starting location conforms to the depth definition of the area/depth sub-stratum that is being sampled. If no such location exists (e.g., too much foul ground or no depth within the current depth definition), then the next grid on the list will be sampled.

10. Tows in the shallowest stratum will be conducted for a maximum of one hour at a speed of 2.2 nmi/hour with no more than ±10% variation. Tows in the two deeper strata will be conducted for a maximum of two hours at a speed of 2.2 nmi/hour with no more than ±10% variation.

11. Once the tow location is selected, the skipper will be asked to tow along the contour in the direction that he determines will result in the best catch rate. Note that this choice will be dictated by currents and other underwater conditions at the time of the tow and is required because catch rates can be very low if the wrong direction is selected. Catches will be monitored and the tow period can be shortened if the tow exceeds 0.5 hours in length and it either appears that the total catch will exceed 2 tonnes or that the towing ground is becoming unfishable.

Table A4. Approximate number of 500 m X 500 m grids in each of the 18 depth/area sub-strata presented in Figure A4.

Longspine Area	**501-800**	**801-1200**	**1201-1600**	**Total all depths**
1. Barkley	1 965	2 756	2 351	7 072
2. Loudon/Clayoquot	1 323	1 478	2 790	5 591
3. Clayoquot/Estevan	1 060	1 517	1 846	4 423
4. Nootka/500 Line	1 059	1 552	1 807	4 418
5. Esperanza/Kyuquot	1 701	1 442	1 041	4 184
6. Cape Cook/Winter Harbour	764	2 160	2 297	5 221
Total	7 872	10 905	12 132	30 909

12. Once a tow is successfully completed in a stratum, the succeeding tow in that stratum is to be the next random tow in the list provided. If that tow is located in a 500 X 500 m grid box that was sampled by the previous tow, then the next random tow on the list should be used.

13. The number of tows presented in Table A2 **must all be completed successfully**. If, for any reason, a tow is deemed not successful while undertaking the survey, the next random grid location in that area/depth sub-stratum must be occupied and the tow repeated. This sequence is to be followed (including selecting the next random grid location each time), until all the tows specified in Table A2 are completed successfully.

14. During each tow, readings from the available net mensuration equipment (wingspread, depth, codend and temperature sensors) will be taken at least every ten minutes of the tow,

Appendix A (cont'd)

starting from when the tow is fully deployed. The bottom contact sensor is attached to the net and the data are to be downloaded after every tow.

Table A5. Percentage distribution of the 500 m X 500 m grids in each of the 18 depth/area sub-strata presented in Figure A4.

Longspine Area	**501-800**	**801-1200**	**1201-1600**	**Total all depths**
Barkley	6.1%	8.7%	7.3%	22.1%
Loudon/Clayoquot	4.2%	4.7%	8.8%	17.7%
Clayoquot/Estevan	3.4%	4.9%	5.9%	14.2%
Nootka/500 Line	3.4%	5.1%	5.9%	14.4%
Esperanza/Kyuquot	5.6%	4.8%	3.5%	13.9%
Cape Cook/Winter Harbour	2.6%	7.3%	7.7%	17.6%
Total	25.4%	35.4%	39.2%	100.0%

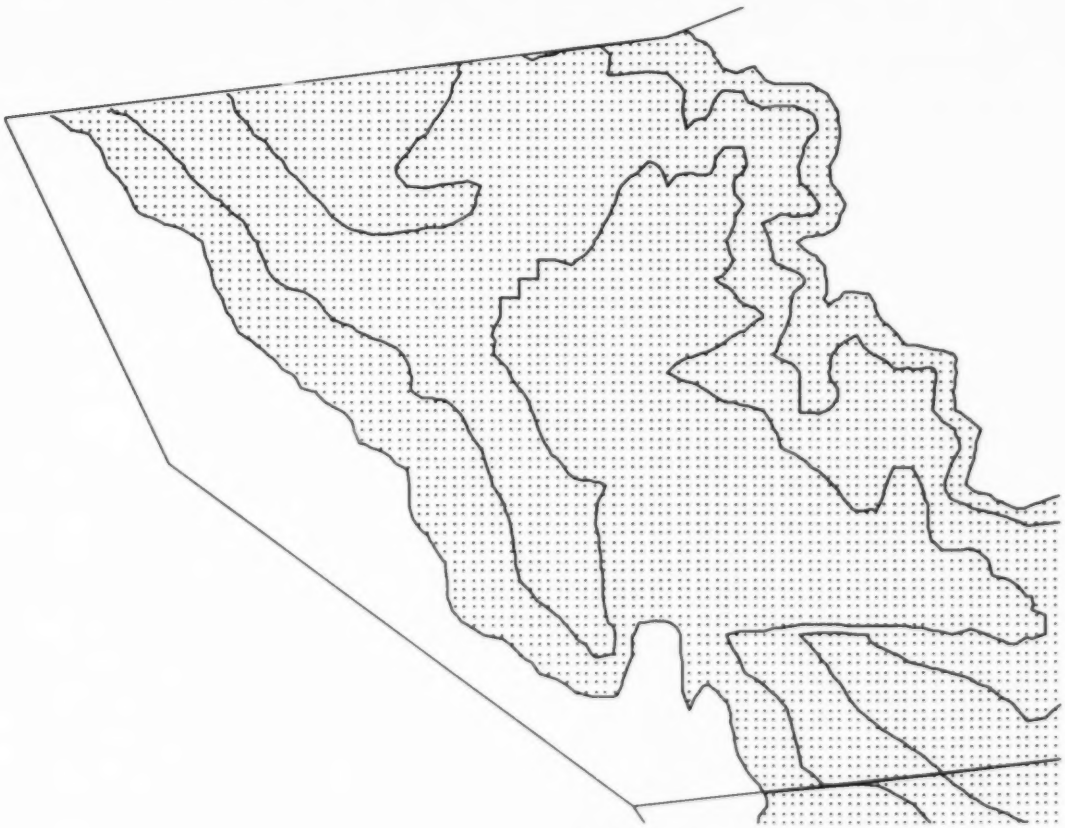

Figure A7. Diagram for areal stratum 6 (Cape Cook/Winter Harbour) showing proposed 500 m X 500 m grid locations from which random locations will be selected (each location is represented by a single dot which may not be readily visible in a printed version of this document).

Appendix A (cont'd)

A8. PROTOCOL FOR SAMPLING SURVEY TOWS

15. For each tow, the following data will be collected:

a. Total catch in **numbers** and **weight** for all commercially important or potentially commercially important species of finfish (including elasmobranchs). This category will be separated out to the species level. If the catch is too large to weigh in aggregate, the total weight must be back-calculated from known weight fish bins.

b. Total catch in numbers and weight for invertebrate species separated to the Family or Order level as appropriate. Crabs (queen and tanner) can be separated into species categories.

c. The following list of species (Table A15) will be sampled for biological characteristics (length, sex and maturity stage). If the catch of that species is too large to sample every fish, then a random sub-sample will be taken for that species. The sub-sample will be weighed to determine the proportion by weight that is sampled of that species.

Table A15. Biological sampling targets by species.

Species	Length/sex/maturity sample (every tow)	Otolith sampling	Target number otoliths	Random age sample
Longspine thornyheads	YES	LENGTH STRATIFIED	1000	1-2 tows
Shortspine thornyheads	YES	LENGTH STRATIFIED	500	1-2 tows
Shortraker rockfish	YES	LENGTH STRATIFIED	200	NO
Rougheye rockfish	YES	LENGTH STRATIFIED	200	NO
Dover sole	YES	LENGTH STRATIFIED	500	1-2 tows
Deepwater sole	YES	LENGTH STRATIFIED	200	NO
Turbot	YES	LENGTH STRATIFIED	200	NO
Sablefish	YES	EVERY FISH	200	NO
Roughscale grenadier	YES	NO	N/A	NO
Pectoral grenadier	YES	NO	N/A	NO

d. Maturity protocols for the appropriate species groupings (flatfish, slope rockfish) will be provided by DFO. There is no specific maturity protocol yet developed in Canada for the thornyhead species. The survey will attempt to implement the rockfish maturity protocol if

Appendix A (cont'd)

it is not possible to obtain a specific thornyhead maturity protocol from the NFMS scientists.

e. Otoliths will be taken for the indicated finfish species. The sampling strategy to be used will be to stratify the expected length distribution by sex and to equally subdivide the indicated number of otoliths into regularly spaced length categories. Otoliths from each length/sex stratum will be collected from the catch as required. Care will be taken to take these otoliths systematically throughout the entire survey (i.e. take only one or two otoliths per length/sex stratum in any one tow).

f. The three species indicated in the above table will also have one to two tows sampled randomly during the survey while the tow is sub-sampled for length/sex/maturity.

g. The fish selected in paragraph 15.e will also be individually weighed to generate a length-weight key.

16. Sampling the catch:

a. The entire catch will be initially sorted by species or invertebrate group. Each category will be then counted and weighed.

b. The entire catch for the species in listed in 15.c will be measured for length and the sex and maturity state for each fish will be determined. If there are more than 100 fish in any category, then that category can be sub-sampled by distributing the fish into a number of partially filled buckets and randomly selecting sufficient buckets to ensure that at least 50 fish from each sex are measured. All fish in a selected bucket are to be measured even if the 50 fish per sex limit has been exceeded. Alternatively, the structure of the sample in the net can be preserved in the bucket sample and the random sample be taken systematically from each bucket until the required number of fish are taken.

c. If the catch is very bimodal for a particular species (e.g. a large number of small, sub-commercial fish and only a few larger commercial-sized fish), then the catch of that species can be sub-divided, with complete enumeration of the large fish category and sub-sampling of the smaller size classes as described in 16.b. If this occurs, then the total weight of each size category needs to be recorded before sub-sampling.

d. Some quality control work will be performed with thornyheads to ascertain if the sub-sampling procedures are obtaining reasonable samples of the length distribution. This work will involve measuring every fish in the catch after the catch has been sub-sampled using the procedure outlined in Paragraph 16.b.

A9. DATA LOGGING

17. All data will be placed in the existing DFO GFBio database. Current versions of the event, catch and biological sampling forms will be used. Additional forms will be developed for data systems that are unique to this survey (e.g. net mensuration capabilities).

18. All data will recorded in hard copy. Data checking will be performed after every tow or in the evening as time permits. On board entry of the data will be attempted but is not expected to be completed.

Appendix A (cont'd)

REFERENCES

Cochran, W.G. 1977. Sampling techniques. 3rd Edition. John Wiley & Sons, New York. 413 p.

Quinn, T.R. and R.B. Deriso. 1999. Quantitative Fish Dynamics. Oxford University Press. 542 p.

Starr, P.J. and R. Haigh. 2000. Assessment of the Canadian longspine thornyhead (*Sebastolobus altivelis*) for 2000. Canadian Stock Assessment Secretariat. Research Document 2000/154. Available from http://www.dfo-mpo.gc.ca/csas/csas/English/Research_Years/2000/2000_154E.htm 66 p.

Starr, P.J. and C. Schwarz. 2000. Feasibility of a bottom trawl survey for three slope groundfish species in Canadian waters. Canadian Stock Assessment Secretariat. Research Document 2000/156. Available from http://www.dfo-mpo.gc.ca/csas/csas/English/Research_Years/2000/2000_156E.htm 42 p.

APPENDIX B: FLATFISH GONAD CONDITION AND MATURITY STAGES.

Maturity Stage	Code	Male (testes)	Female (ovaries)
Immature	1	very small, string-like and somewhat translucent or pinkish in colour.	very small, translucent or pinkish in colour and somewhat gelatinous in texture.
Maturing	2	enlarged, a distinct bulge evident but still translucent or pinkish in colour.	relatively small, pinkish-yellow or cream in colour, granular in texture. No distinct eggs visible.
Developing	3	enlarged, brown-white or white in colour, firm in texture.	large, cream or yellow in colour, containing opaque eggs that can be distinguished by direct observation. Sex may be determined externally.
Ripe	4	large, white and easily broken. No sperm evident.	containing partly or wholly translucent eggs. Sex easily determined externally.
Spawning	5	large, white and sperm evident.	containing entirely translucent, mature ova. Eggs loose and will run from oviducts under slight pressure.
Spent	6	flaccid, shrunken and yellow-brown in colour. Sperm ducts enlarged and a small amount of sperm may be present.	large, flaccid and purple in colour. A few translucent eggs may be left. Ovarian membrane very bloodshot and sac-like.
Resting	7	firm, small and yellow-brown in colour. Sperm ducts small.	contracted and firm, pinkish-grey to cream-yellow in colour and may appear granular in texture but no distinct eggs are visible.

APPENDIX C: ROCKFISH (*SEBASTES* SPP.) GONAD CONDITION AND MATURITY STAGES.

Maturity Code	Male (testes)	Female (ovaries)
0	**Unknown**	**Unknown**
1	**Immature** - thread-like and translucent pink in colour.	**Immature** - small, translucent pink in colour.
2	**Maturing** - string-like, with slight swelling evident but still translucent.	**Maturing** - small, yellow eggs visible. Translucent or opaque.
3	**Developing** - swelling, brown-white in colour.	**Mature** - large, yellow or orange eggs. Opaque.
4	**Developed** - large, white and easily broken.	**Fertilized** – large orange-yellow eggs. Translucent.
5	**Running** – running sperm.	**Embryos or larvae** – include eyed eggs. Translucent.
6	**Spent** – white-brown in colour. Sperm still present in duct.	**Spent** - large, flaccid, red in colour. A few larvae may be present.
7	**Resting** - triangular in cross-section. Small and brown in colour.	**Resting** – moderate size, firm, orange-grey in colour. Some with dark blotches.

APPENDIX D: ANALYTICAL METHODS

The biomass estimate (B_s) for species s from the survey is calculated in kg as follows:

$$B_s = \sum_i {C_{s_i} A_i}/{w} \qquad \textbf{Eq. 1}$$

where C_{s_i} = mean CPUE (kg/km) for species s in stratum i

A_i = area of stratum i (km^2)

w = effective fishing width of net (km)

The variance of the survey biomass estimate V_{B_s} for species s is calculated in kg^2 as follows:

$$V_{B_s} = \sum_i {V_{s_i} A_i^2}/{w^2 n_i} \qquad \textbf{Eq. 2}$$

where V_{s_i} = variance of CPUE (kg^2/km^2) for species s in stratum i

n_i = number of observations in stratum i

The distance travelled (D_{ij}) by tow j in stratum i was calculated from intermediate observations within a tow where elapsed time and speed were noted in approximate 10-minute intervals:

$$D_{ij} = \sum_t S_{ijt} T_{ijt} \qquad \textbf{Eq. 3}$$

S_{ijt} = speed (km/h) for tow j in stratum i over time interval t

T_{ijt} = length of time interval t (h) for tow j in stratum i

C_{s_i} (CPUE (kg/km) for species s) is then calculated in one of two ways:

$$C_{s_i} = \frac{\sum_j \left(W_{s_{ij}} / D_{ij} \right)}{J_i} \qquad \textbf{Eq. 4}$$

where $W_{s_{ij}}$ = catch weight (kg) for species s in stratum i and tow j

J_i = number of tows in stratum i

or:

$$C_{s_i} = \frac{\sum_j \left(\left[W_{s_{ij}} / H_{ij} \right] / \left[D_{ij} / E_{ij} \right] \right)}{J_i} \qquad \textbf{Eq. 5}$$

Appendix D (cont'd)

where H_{ij} = elapsed time (h) with confirmed bottom contact for tow j in stratum i

E_{ij} = elapsed time (h) between winch lockup and tow retrieval for tow j in stratum i

Therefore W_{sij}/H_{ij} is the CPUE (kg/h) for species s which is corrected for the amount of time the net is on the bottom and D_{ij}/E_{ij} is the average speed of the net (km/h) for tow j in stratum i.

When investigating the data to determine the benefits of stratification, the estimate of variance provided in Eq. 2 must be adjusted upward to provide an estimate of variance without stratification (Cochran 1977; Section 5a.11, page 136):

$$\hat{V}_{B_s}^{nostrat} = \frac{1}{n}\left[\frac{A}{w}\sum_{i=1}^{I}\frac{A_i}{wn_i}SS_i - B_s^2 + V_{B_s}\right] \qquad \textbf{Eq. 6}$$

where $\hat{V}_{B_s}^{nostrat}$ is the adjusted variance estimate,

A and n are respectively the total area and total number of tows for the complete survey,

and SS_i is the sum of squares of the CPUE term as defined in Eq. 4 or Eq. 5.

Eq. 6 can be modified to estimate the variance for other stratification schemes (such as by depth zone or by area). The estimated variance would be calculated across all areas (for a depth zone effect) or across all depths (for an area effect), with the A, n, B_s and V_{B_s} terms modified to fit the summarisation option chosen. The variances are then summed to give a total variance for the survey.

The precision of the survey is often expressed in terms of the relative error (RE) which is approximated from the values obtained in Eq. 1 and Eq. 2:

$$RE_{B_s} = \frac{\sqrt{V_{B_s}}}{B_s} \qquad \textbf{Eq. 7}$$

where RE_{B_s} is the relative error for species s.

The relationship of weight from length is usually expressed as follows (Quinn & Deriso 1999):

$$Z_{sijk} = a_s L_{sijk}^{b_s} e^{\varepsilon_{sijk}} \qquad \textbf{Eq. 8}$$

where Z_{sijk} is the weight of observation k of species s with length L_{sijk} from tow j in stratum I,

a_s and b_s are species regression constants and e_{sijk} is a random error term with mean 0 and constant variance s^2

Appendix D (cont'd)

The sample for any species was scaled up to the catch in the sampled tow as follows:

$$S_{sijk} = \frac{Z_{sijk}}{\sum_{k} Z_{sijk}} W_{s_{ij}} \qquad \textbf{Eq. 9}$$

where S_{sijk} is the scaled weight (in kg) of observation k of species s from tow j in stratum i.

As S_{sijk} is equivalent to the catch weight $\left(W_{s_{ij}}\right)$ in Eq. 4 and Eq. 5, S_{sijk} can be substituted into these equations instead of $W_{s_{ij}}$ and then the corresponding CPUE estimate can be used in Eq. 1 and Eq. 2 to calculate the mean and standard error of any sub-group of the biomass. Length distributions were calculated by binning the lengths into 1 cm intervals (for longspines) and into 5 cm intervals (for shortspines, the two rattail species and Dover sole).

As there are tows with non-zero catch which were not sampled for the latter five species, the distribution of the unsampled tows was estimated from the mean distribution of the sampled tows within any area/depth zone stratum. A further complication arose because the two rattail species (pectoral and roughscale) were not sampled at all in some of the 500-800 m depth zones so this method could not be used to estimate the unsampled catch. Therefore, the length distributions for these two species could only be estimated after combining all the areal strata into three depth zone strata.

APPENDIX E: BRIDGE LOG AND HAUL INFORMATION BY TOW FOR THE *F/V VIKING STORM* THORNYHEAD BIOMASS SURVEY, SEPTEMBER 15 TO OCTOBER 2, 2001. SEE END OF APPENDIX FOR EXPLANATORY NOTES.

Haul No.	1	2	3	4	5	6
Date	Sept. 15	Sept. 15	Sept. 15	Sept. 15	Sept. 16	Sept. 16
Start Time (24 h)	0943	1410	2125	2307	0747	1126
Duration (min)[1]	58	60	20	60	66	70
Bottom Contact (min)[2]	39.0	42.1	2.9	49.1	34.7	41.2
Area (Major, Minor)[3]	03 23	03 23	03 23	03 23	03 23	03 23
Start N. Lat. (Deg)	48	48	48	48	48	48
(Min)	31.3	32.0	16.1	16.2	16.3	10.9
W. Long. (Deg)	126	126	126	126	126	126
(Min)	15.9	23.2	12.6	12.8	5.8	6.8
Finish N. Lat. (Deg)	48	48	48	48	48	48
(Min)	33.5	32.5	16.3	18.8	14.6	9.1
W. Long. (Deg)	126	126	126	126	126	126
(Min)	15.8	26.2	11.4	13.6	8.3	3.9
Direction (Deg. True)[4]	187	286	61	340	246	114
Tow Distance (Km)[5]	4.12	3.60	1.7*	4.29	4.62	5.00
Mean Depth (m)[6]	749	1161	1265	1095	1346	1027
Remarks	usable	usable	unusable	usable	usable	usable
Rockfish						
Shortspine thornyhead	57.8	12.9	..	19.6	3.9	19.5
Longspine thornyhead	29.5	37.2	2.1	69.2	5.7	96.2
Other rockfish[7]	..	..	..	..	..	..
Flatfish						
Dover sole	14.2	1.3	..	..	..	..
Deepsea sole	1.6	2.5	..	0.6	0.8	0.9
Arrowtooth flounder	..	..	..	..	..	..
Rex sole	..	..	..	..	..	..
Roundfish						
Sablefish	229.4	80.7	..	48.5	30.8	77.1
Pacific cod	..	..	..	..	..	..
Pacific hake	..	..	..	..	..	..
Miscellaneous fish						
Roughscale rattail	2.9	101.7	0.1	189.1	152.8	21.5
Pectoral rattail	6.0	49.4	3.7	33.6	17.7	9.3
Pacific flatnose	0.8	0.1	0.1	4.6	17.3	0.1
Eelpouts	0.2	0.1	..	..	..	..
Other[8]	0.1	1.0	0.1	0.1	0.2	0.9
Elasmobranchii						
Deepsea skate	..	..	..	..	..	..
Black skate	..	..	..	..	1.1	3.3
Longnose skate	12.2	..	..	..	..	..
Sharks[9]	0.1	0.7	..	13.6	..	..
Invertebrates						
Tanner crab	2.3	6.4	0.7	..	..	1.9
Brittle stars	..	..	..	..	..	..
Squid	0.1	1.0	..	..	..	..
Anemones	..	1.7	..	0.1	1.0	..
Other[10]	0.1	2.7	1.1	13.4	1.5	0.9
TOTAL CATCH (Kg)	**357.3**	**299.4**	**7.9**	**392.4**	**232.8**	**231.6**

Appendix E (cont'd)

Haul No.	7	8	9	10	11	12
Date	Sept. 16	Sept. 16	Sept. 16	Sept. 17	Sept. 17	Sept. 17
Start Time (24 h)	1550	1910	2200	0732	1225	1639
Duration (min)[1]	70	60	60	82	70	60
Bottom Contact (min)[2]	42.7	52.4	61.1	60.8[†]	55.1	28.6
Area (Major, Minor)[3]	03 23	03 23	03 23	03 23	03 23	03 23
Start N. Lat. (Deg)	48	48	48	48	48	48
(Min)	21.8	25.1	25.6	19.4	27.9	37.7
W. Long. (Deg)	125	126	126	126	126	126
(Min)	55.7	13.9	11.9	27.0	25.2	14.8
Finish N. Lat. (Deg)	48	48	48	48	48	48
(Min)	20.6	27.0	27.7	27.0	29.2	35.3
W. Long. (Deg)	125	126	126	126	126	126
(Min)	59.1	15.9	13.1	27.0	22.5	15.8
Direction (Deg. True)[4]	235	321	343	6	23	201
Tow Distance (Km)[5]	5.28	4.32	4.48	5.54	4.91	4.23
Mean Depth (m)[6]	676	720	552	1495	1135	637
Remarks	usable	usable	usable	usable	usable	Usable
Rockfish						
Shortspine thornyhead	21.9	29.0	64.4	12.6	9.3	136.1
Longspine thornyhead	114.2	14.7	4.0	57.2	56.2	7.2
Other rockfish[7]	..	..	9.6	..	..	2.7
Flatfish						
Dover sole	76.9	57.2	55.4	1.5	..	2.1
Deepsea sole	..	4.8	0.5	0.5	2.4	..
Arrowtooth flounder	..	..	..	..	..	..
Rex sole	0.8	..	0.1	..	..	0.1
Roundfish						
Sablefish	528.0	51.2	37.2	4.8	42.6	277.6
Pacific cod	..	..	..	..	..	..
Pacific hake	..	..	5.3	..	..	..
Miscellaneous fish						
Roughscale rattail	0.5	18.1	..	116.5	203.2	3.2
Pectoral rattail	1.9	6.8	11.1	150.1	100.2	10.3
Pacific flatnose	2.0	1.5	2.5	41.2	4.4	0.7
Eelpouts	8.3	0.9	0.1	7.6	..	0.2
Other[8]	4.8	0.3	0.1	0.0	3.3	0.0
Elasmobranchii						
Deepsea skate	..	..	..	..	..	2.6
Black skate	1.4	..	..	9.1	..	2.6
Longnose skate	8.0	4.8	12.5	86.4	..	1.9
Sharks[9]	1.9	1.4	0.6	..	..	0.1
Invertebrates						
Tanner crab	..	..	4.0	5.9	1.8	2.5
Brittle stars	..	..	..	..	..	..
Squid	10.7	1.4	..	7.5	..	2.6
Anemones	..	1.0	0.1	0.1	5.1	..
Other[10]	0.9	0.1	0.2	4.9	4.0	1.9
TOTAL CATCH (Kg)	**782.2**	**193.1**	**207.5**	**505.9**	**432.5**	**454.4**

Appendix E (cont'd)

Haul No.	13	14	15	16	17	18
Date	Sept. 17	Sept. 18	Sept. 18	Sept. 18	Sept. 18	Sept. 19
Start Time (24 h)	1915	0040	0642	1000	1219	0619
Duration (min)[1]	60	80	80	70	60	60
Bottom Contact (min)[2]	36.2	84.6	89.2	46.3	22.5	62.2
Area (Major, Minor)[3]	03 23	03 24	03 24	03 24	03 24	03 24
Start N. Lat. (Deg)	48	48	48	48	48	48
(Min)	38.0	40.0	43.6	48.1	48.0	42.7
W. Long. (Deg)	126	126	126	126	126	126
(Min)	19.8	37.7	48.3	43.0	40.8	31.3
Finish N. Lat. (Deg)	48	48	48	48	48	48
(Min)	39.7	41.7	45.5	50.7	45.8	44.3
W. Long. (Deg)	126	126	126	126	126	126
(Min)	22.0	41.3	51.7	41.6	39.8	34.0
Direction (Deg. True)[4]	326	293	310	22	174	307
Tow Distance (Km)[5]	3.98	5.65	5.56	4.91	4.3	4.29
Mean Depth (m)[6]	698	1318	1405	991	991	667
Remarks	usable	usable	usable	usable	usable	usable
Rockfish						
Shortspine thornyhead	64.4	11.4	0.6	21.5	14.7	29.8
Longspine thornyhead	50.6	56.6	25.4	108.1	25.1	9.2
Other rockfish[7]	..	..	..	..	..	..
Flatfish						
Dover sole	54.4	0.8	..	7.4	1.2	96.7
Deepsea sole	..	1.3	3.3	3.1	1.1	..
Arrowtooth flounder	..	..	..	..	..	..
Rex sole	..	..	..	..	..	..
Roundfish						
Sablefish	171.9	18.6	8.6	88.9	16.7	27.1
Pacific cod	..	..	..	..	..	..
Pacific hake	..	..	..	..	..	..
Miscellaneous fish						
Roughscale rattail	3.5	189.6	217.7	146.9	10.1	1.9
Pectoral rattail	17.7	161.0	240.0	57.1	3.6	39.9
Pacific flatnose	1.8	17.6	40.0	7.0	0.1	6.8
Eelpouts	3.4	2.1	1.8	1.0	0.1	3.3
Other[8]	1.1	0.2	0.0	7.5	1.2	0.2
Elasmobranchii						
Deepsea skate	..	..	..	..	..	..
Black skate	1.7	..	6.6	3.6	..	1.5
Longnose skate	8.2	18.4	..	..	..	5.0
Sharks[9]	..	..	..	0.6	..	0.1
Invertebrates						
Tanner crab	6.7	5.6	3.7	31.9	7.3	6.6
Brittle stars	..	..	100.0	25.0	..	..
Squid	..	..	..	..	..	2.0
Anemones	1.0	18.1	1.0	0.1	..	0.1
Other[10]	2.9	1.5	1.0	0.9	..	0.3
TOTAL CATCH (Kg)	**389.3**	**502.8**	**649.7**	**510.6**	**81.2**	**230.5**

Appendix E (cont'd)

Haul No.	19	20	21	22	23	24
Date	Sept. 19	Sept. 19	Sept. 19	Sept. 19	Sept. 20	Sept. 20
Start Time (24 h)	0922	1337	1736	1950	1155	1628
Duration (min)[1]	60	88	60		60	66
Bottom Contact (min)[2]	46.8	66.9	38.8	47.2	41.6	43.4
Area (Major, Minor)[3]	03 24	03 24	03 24	03 24	03 23	03 24
Start N. Lat. (Deg)	48	48	48	48	48	48
(Min)	41.5	51.4	53.9	56.1	35.0	46.3
W. Long. (Deg)	126	126	126	126	126	126
(Min)	31.1	42.5	38.6	45.2	22.0	53.3
Finish N. Lat. (Deg)	48	48	48	48	48	48
(Min)	43.1	48.4	54.6	57.0	36.9	47.8
W. Long. (Deg)	126	126	126	126	126	126
(Min)	33.4	43.3	41.8	48.1	23.3	56.1
Direction (Deg. True)[4]	325	200	290	306	349	313
Tow Distance (Km)[5]	4.26	5.58	4.33	4.6*	4.01	2.33
Mean Depth (m)[6]	729	1065	556	679	964	1491
Remarks	usable	usable	usable	unusable	usable	Usable
Rockfish						
Shortspine thornyhead	40.7	28.8	39.2	21.3	22.3	6.3
Longspine thornyhead	37.3	315.9	9.5	15.9	77.8	3.5
Other rockfish[7]	..	..	..	..	..	..
Flatfish						
Dover sole	83.9	8.9	13.8	30.9	56.8	6.1
Deepsea sole	2.3	2.2	..	0.6	3.7	..
Arrowtooth flounder	..	..	1.8	..	..	..
Rex sole	..	..	..	..	..	..
Roundfish						
Sablefish	89.8	121.6	..	74.4	67.1	5.1
Pacific cod	..	..	..	..	..	..
Pacific hake	..	..	..	0.8	..	..
Miscellaneous fish						
Roughscale rattail	4.7	115.2	1.8	0.8	5.0	68.9
Pectoral rattail	7.7	95.7	19.5	9.0	14.5	50.3
Pacific flatnose	1.5	16.1	5.6	2.9	0.7	25.7
Eelpouts	2.2	7.4	0.7	0.1	0.8	..
Other[8]	1.5	3.9	4.1	2.6	2.1	1.2
Elasmobranchii						
Deepsea skate	..	..	..	..	..	2.5
Black skate	..	..	..	..	..	..
Longnose skate	10.2	..	4.2	..	5.1	..
Sharks[9]	0.1	0.6	1.2	..	0.1	..
Invertebrates						
Tanner crab	4.5	80.0	2.2	7.7	6.8	18.3
Brittle stars	..	..	..	..	..	0.5
Squid	3.1	0.6	..	9.9	1.2	0.1
Anemones	0.1	0.1	0.1	..	0.1	0.1
Other[10]	1.1	4.2	9.2	2.7	0.2	2.4
TOTAL CATCH (Kg)	**290.7**	**801.2**	**112.9**	**179.6**	**264.3**	**191.0**

Appendix E (cont'd)

Haul No.	25	26	27	28	29	30
Date	Sept. 20	Sept. 20	Sept. 21	Sept. 21	Sept. 21	Sept. 21
Start Time (24 h)	1905	2132	0633	1032	1326	1615
Duration (min)[1]	70	70	70	86	70	70
Bottom Contact (min)[2]	45.5	68.9	64.3	59.1	54.9	45.5
Area (Major, Minor)[3]	03 24	03 24	03 24	03 24	03 24	04 25
Start N. Lat. (Deg)	48	48	48	48	48	49
(Min)	51.5	54.0	58.8	46.3	52.9	1.4
W. Long. (Deg)	126	126	126	126	126	127
(Min)	55.0	52.0	50.8	54.3	54.6	0.5
Finish N. Lat. (Deg)	48	48	48	48	48	49
(Min)	54.2	52.2	57.3	49.3	55.4	3.8
W. Long. (Deg)	126	126	126	126	126	127
(Min)	55.0	49.2	47.8	52.6	56.6	1.5
Direction (Deg. True)[4]	..	117	134	27	336	348
Tow Distance (Km)[5]	5.00	4.78	4.96	6.01	4.91	4.82
Mean Depth (m)[6]	1052	1062	657	1388	999	1050
Remarks	usable	usable	usable	usable	usable	usable
Rockfish						
Shortspine thornyhead	14.2	23.7	33.5	2.0	15.7	24.8
Longspine thornyhead	90.0	109.6	14.6	5.0	81.3	102.0
Other rockfish[7]	..	..	..	..	..	..
Flatfish						
Dover sole	4.3	9.8	2.9	0.1	..	..
Deepsea sole	..	1.8	..	1.5	..	0.8
Arrowtooth flounder	..	..	..	..	..	..
Rex sole	..	..	..	..	..	..
Roundfish						
Sablefish	67.6	40.4	103.6	8.2	28.1	52.6
Pacific cod	..	..	..	..	..	..
Pacific hake	..	..	..	..	..	..
Miscellaneous fish						
Roughscale rattail	44.5	43.5	3.0	210.0	37.2	35.8
Pectoral rattail	33.1	48.1	20.4	33.1	11.8	24.9
Pacific flatnose	0.8	3.3	7.7	30.3	1.5	1.4
Eelpouts	2.8	2.1	1.9	1.5	0.2	1.5
Other[8]	3.3	0.5	0.4	0.5	0.9	1.1
Elasmobranchii						
Deepsea skate	..	2.9	..	2.7	..	..
Black skate	2.9	..	0.1	0.1	..	..
Longnose skate	..	..	..	..	..	..
Sharks[9]	..	0.1	..	..	..	..
Invertebrates						
Tanner crab	30.3	13.1	..	6.7	34.7	0.1
Brittle stars	..	0.1	0.1	..	..	..
Squid	1.0	0.1	5.2	6.0	1.0	..
Anemones	6.8	0.1	0.1	0.1	1.5	0.1
Other[10]	7.8	0.5	4.5	25.2	17.4	0.4
TOTAL CATCH (Kg)	**309.4**	**299.7**	**198.0**	**333.0**	**231.3**	**245.5**

Appendix E (cont'd)

Haul No.	31	32	33	34	35	36
Date	Sept. 21	Sept. 21	Sept. 22	Sept. 22	Sept. 22	Sept. 22
Start Time (24 h)	1844	2048	0610	0923	1348	1643
Duration (min)[1]	60	70	81	70	70	..
Bottom Contact (min)[2]	61.3	65.3	81.7	64.4	35.0	11.4
Area (Major, Minor)[3]	04 25	04 25	04 25	04 25	04 25	04 25
Start N. Lat. (Deg)	49	49	49	49	49	49
(Min)	4.3	5.4	12.2	14.3	12.8	16.1
W. Long. (Deg)	127	127	127	127	127	127
(Min)	..	..	13.1	20.1	9.1	12.0
Finish N. Lat. (Deg)	49	49	49	49	49	49
(Min)	2.5	8.0	14.0	11.8	10.4	17.9
W. Long. (Deg)	126	127	127	127	127	127
(Min)	57.8	1.1	16.8	20.0	9.2	13.6
Direction (Deg. True)[4]	160	341	317	184	71	335
Tow Distance (Km)[5]	4.01	5.19	5.63	4.87	4.51	4.32
Mean Depth (m)[6]	692	702	1456	1432	1097	957
Remarks	usable	usable	usable	usable	usable	unusable
Rockfish						
Shortspine thornyhead	19.6	21.6	5.1	0.1	19.1	9.4
Longspine thornyhead	26.1	17.1	11.0	8.9	143.7	58.2
Other rockfish[7]	..	..	..	..	..	..
Flatfish						
Dover sole	19.1	41.4	1.5	0.1	..	..
Deepsea sole	..	0.1	..	6.1	2.0	2.6
Arrowtooth flounder	..	..	..	..	..	..
Rex sole	..	..	..	..	..	..
Roundfish						
Sablefish	57.8	88.9	7.0	..	91.2	42.2
Pacific cod	..	..	..	..	..	..
Pacific hake	..	..	..	..	..	..
Miscellaneous fish						
Roughscale rattail	4.1	2.0	235.9	134.3	28.1	13.7
Pectoral rattail	5.2	7.3	206.4	178.3	25.4	2.4
Pacific flatnose	..	3.2	33.4	48.3	1.0	0.1
Eelpouts	1.0	0.2	..	2.0	0.1	0.1
Other[8]	1.2	0.5	0.3	2.0	0.5	1.8
Elasmobranchii						
Deepsea skate	..	..	..	20.6	..	..
Black skate	..	..	0.1	5.1	..	..
Longnose skate	3.1	..	3.6	..	..	..
Sharks[9]	..	0.1	..	..	0.1	1.0
Invertebrates						
Tanner crab	3.4	9.7	10.3	6.0	6.6	4.9
Brittle stars	..	..	..	4.7	5.0	..
Squid	4.8	2.0	3.7	..	..	0.1
Anemones	..	0.1	9.9	6.9	..	0.1
Other[10]	1.4	0.1	0.8	6.6	5.5	1.2
TOTAL CATCH (Kg)	**146.8**	**194.3**	**529.0**	**430.0**	**328.3**	**137.8**

Appendix E (cont'd)

Haul No.	37	38	39	40	41	42
Date	Sept. 22	Sept. 22	Sept. 23	Sept. 23	Sept. 23	Sept. 23
Start Time (24 h)	1918	2146	0542	0835	1050	1306
Duration (min)[1]	70	70	70	66	70	54
Bottom Contact (min)[2]	56.3	30.1	37.9	54.6	47.2	51.1
Area (Major, Minor)[3]	04 25	04 25	04 25	04 26	04 26	04 26
Start N. Lat. (Deg)	49	49	49	49	49	49
(Min)	18.8	18.3	30.8	35.2	38.5	38.2
W. Long. (Deg)	127	127	127	127	127	127
(Min)	13.1	16.1	21.9	29.1	31.8	25.4
Finish N. Lat. (Deg)	49	49	49	49	49	49
(Min)	16.5	20.5	32.0	36.9	37.9	38.7
W. Long. (Deg)	127	127	127	127	127	127
(Min)	10.6	17.9	24.0	31.8	27.9	28.3
Direction (Deg. True)[4]	136	332	327	324	102	280
Tow Distance (Km)[5]	5.07	4.78	4.78	4.70	4.72	4.1*
Mean Depth (m)[6]	648	1118	935	760	736	607
Remarks	usable	usable	usable	usable	usable	unusable
Rockfish						
Shortspine thornyhead	34.8	9.6	14.4	57.7	46.3	42.0
Longspine thornyhead	22.8	63.6	84.2	39.6	26.5	13.9
Other rockfish[7]	..	1.8	..	..	..	91.2
Flatfish						
Dover sole	83.9	1.2	8.2	40.4	39.2	17.1
Deepsea sole	..	2.6	3.0	..	0.8	0.1
Arrowtooth flounder	5.8	..	..	..	..	40.7
Rex sole	..	..	..	..	..	..
Roundfish						
Sablefish	39.9	65.8	122.5	84.9	242.7	435.4
Pacific cod	..	4.0	..	..	..	3.0
Pacific hake	..	..	..	..	..	34.4
Miscellaneous fish						
Roughscale rattail	8.2	52.2	1.4	7.4	5.9	1.9
Pectoral rattail	..	42.2	20.8	5.5	9.1	13.2
Pacific flatnose	9.7	..	0.1	2.6	0.7	..
Eelpouts	4.7	..	0.1	..	1.3	..
Other[8]	0.1	1.8	0.5	1.1	0.4	0.0
Elasmobranchii						
Deepsea skate	..	..	5.2	2.4	3.2	2.4
Black skate	..	..	..	..	..	..
Longnose skate	4.4	1.8	..	..	..	40.6
Sharks[9]	..	..	0.1	1.7	1.2	..
Invertebrates						
Tanner crab	6.5	3.5	13.3	2.9	1.4	6.0
Brittle stars	0.1	..	..	..	..	..
Squid	2.0	1.3	2.5	3.5	6.1	18.9
Anemones	0.1	0.1	..	..	..	1.2
Other[10]	0.2	0.1	0.7	12.0	2.0	1.1
TOTAL CATCH (Kg)	**223.3**	**251.6**	**277.0**	**261.7**	**386.8**	**763.1**

Appendix E (cont'd)

Haul No.	43	44	45	46	47	48
Date	Sept. 23	Sept. 23	Sept. 24	Sept. 25	Sept. 25	Sept. 25
Start Time (24 h)	1531	1938	0530	0707	1042	1406
Duration (min)[1]	81	72	90	76	56	71
Bottom Contact (min)[2]	64.3	52.1	87.4	71.7	42.8	54.7
Area (Major, Minor)[3]	04 26	04 25	04 26	04 26	04 26	04 26
Start N. Lat. (Deg)	49	49	49	49	49	49
(Min)	39.9	32.0	30.2	39.1	35.8	32.5
W. Long. (Deg)	127	127	127	127	127	127
(Min)	31.0	23.8	38.7	37.6	40.1	41.4
Finish N. Lat. (Deg)	49	49	49	49	49	49
(Min)	37.7*	31.9	27.2	41.6	34.4	30.7
W. Long. (Deg)	127	127	127	127	127	127
(Min)	28.0*	19.7	37.0	35.4	37.8	39.6
Direction (Deg. True)[4]	133	92	157	42	135	148
Tow Distance (Km)[5]	5.54	5.0*	6.08	5.22	3.80	5.01
Mean Depth (m)[6]	694	878	1144	558	676	939
Remarks	usable	unusable	usable	usable	usable	usable
Rockfish						
Shortspine thornyhead	53.0	24.4	37.9	68.1	39.5	24.8
Longspine thornyhead	28.2	132.2	110.9	9.7	10.6	77.3
Other rockfish[7]	2.4	..	..	5.8	..	..
Flatfish						
Dover sole	19.3	10.7	..	11.9	1.8	1.2
Deepsea sole	..	9.8	4.4	..	..	1.8
Arrowtooth flounder	7.5	..	..	3.8	..	..
Rex sole	..	..	..	..	..	..
Roundfish						
Sablefish	410.5	116.1	36.8	45.2	8.0	31.7
Pacific cod	..	..	..	..	..	..
Pacific hake	1.0	..	..	0.5	..	..
Miscellaneous fish						
Roughscale rattail	0.1	11.3	150.1	..	4.0	22.3
Pectoral rattail	19.1	14.2	20.9	7.9	..	9.3
Pacific flatnose	0.1	1.5	5.1	2.7	4.1	2.5
Eelpouts	3.0	2.7	..	..	0.1	0.7
Other[8]	0.2	2.2	2.7	0.2	0.6	3.4
Elasmobranchii						
Deepsea skate	1.5	..	..	2.5	..	..
Black skate	..	..	..	..	..	1.5
Longnose skate	..	..	..	51.9	3.8	..
Sharks[9]	0.5	0.1	..	0.8	0.1	0.7
Invertebrates						
Tanner crab	0.6	13.6	1.8	7.0	1.1	2.5
Brittle stars	..	..	..	..	..	..
Squid	15.7	1.6	0.6	2.9	0.5	3.5
Anemones	..	..	1.5	..	..	0.1
Other[10]	3.4	0.2	2.7	1.2	..	2.9
TOTAL CATCH (Kg)	**566.1**	**340.6**	**375.4**	**222.1**	**74.2**	**186.2**

Appendix E (cont'd)

Haul No.	49	50	51	52	53	54
Date	Sept. 25	Sept. 25	Sept. 26	Sept. 26	Sept. 26	Sept. 26
Start Time (24 h)	1841	2145	0658	1118	1433	1928
Duration (min)[1]	80	56	67	57	70	59
Bottom Contact (min)[2]	67.5	43.5	27.6	45.6	72.6	51.5
Area (Major, Minor)[3]	04 26	04 26	04 26	04 26	04 26	04 26
Start N. Lat. (Deg)	49	49	49	49	49	49
(Min)	34.0	34.2	40.6	43.6	39.7	34.9
W. Long. (Deg)	127	127	127	127	127	127
(Min)	42.9	42.4	49.6	40.5	38.2	47.0
Finish N. Lat. (Deg)	49	49	49	49	49	49
(Min)	36.9	36.3	41.2	45.0	42.2	36.4
W. Long. (Deg)	127	127	127	127	127	127
(Min)	44.5	43.3	45.8	43.1	37.1	48.9
Direction (Deg. True)[4]	321	345	80	315	20	315
Tow Distance (Km)[5]	5.37	3.83	4.62	3.82	4.68	4.04
Mean Depth (m)[6]	928	988	1112	642	562	1327
Remarks	usable	usable	usable	usable	usable	usable
Rockfish						
Shortspine thornyhead	60.8	18.7	20.2	55.1	68.1	8.6
Longspine thornyhead	134.5	96.0	132.9	108.2	9.6	4.4
Other rockfish[7]	..	..	..	..	..	..
Flatfish						
Dover sole	6.9	18.0	1.3	48.5	26.3	0.1
Deepsea sole	6.2	1.4	1.8	1.0	0.6	..
Arrowtooth flounder	..	..	..	..	..	..
Rex sole	..	..	..	..	..	..
Roundfish						
Sablefish	38.3	41.2	78.6	145.2	28.7	9.7
Pacific cod	..	..	..	..	..	..
Pacific hake	..	..	..	..	..	..
Miscellaneous fish						
Roughscale rattail	24.2	..	64.8	102.6	1.0	45.2
Pectoral rattail	16.4	14.3	24.6	30.7	6.7	32.4
Pacific flatnose	1.8	0.1	2.1	..	5.0	9.6
Eelpouts	1.2	0.5	3.1	..	1.8	1.0
Other[8]	7.9	6.8	2.8	0.4	1.1	0.1
Elasmobranchii						
Deepsea skate	..	..	..	..	0.3	1.0
Black skate	2.0	0.1	..	0.9	..	..
Longnose skate	..	..	..	..	8.2	22.6
Sharks[9]	..	0.1	..	0.1	1.8	1.2
Invertebrates						
Tanner crab	13.4	11.1	5.5	12.7	3.6	15.5
Brittle stars	..	..	..	..	0.1	..
Squid	0.1	..	..	3.7	0.9	1.2
Anemones	0.1	..	0.1	0.6	0.1	0.1
Other[10]	0.2	0.4	0.2	0.9	2.2	8.6
TOTAL CATCH (Kg)	**314.0**	**208.7**	**338.0**	**510.6**	**166.1**	**161.3**

Appendix E (cont'd)

Haul No.	55	56	57	58	59	60
Date	Sept. 26	Sept. 28	Sept. 28	Sept. 28	Sept. 28	Oct. 1
Start Time (24 h)	2235	0710	1035	1433	1750	1205
Duration (min)[1]	57	60	68	64	70	60
Bottom Contact (min)[2]	47.0	31.1	43.9	45.3	50.6	25.9
Area (Major, Minor)[3]	04 26	04 27	04 27	04 27	04 27	04 26
Start N. Lat. (Deg)	49	50	50	50	50	49
(Min)	34.6	9.4	10.2	11.2	3.9	54.2
W. Long. (Deg)	127	128	128	128	128	127
(Min)	47.1	28.4	25.0	25.1	21.4	55.3
Finish N. Lat. (Deg)	49	50	50	50	50	49
(Min)	36.3	10.9	8.5	12.9	1.5	56.2
W. Long. (Deg)	127	128	128	128	128	127
(Min)	49.1	30.9	24.9	22.5	19.9	56.8
Direction (Deg. True)[4]	310	315	183	40	158	324
Tow Distance (Km)[5]	3.87	4.14	4.62	4.41	4.82	4.17
Mean Depth (m)[6]	1293	998	1001	1076	1100	668
Remarks	usable	usable	usable	usable	usable	usable
Rockfish						
Shortspine thornyhead	5.6	13.8	22.3	5.4	19.7	50.5
Longspine thornyhead	4.6	55.3	173.7	63.8	45.3	48.7
Other rockfish[7]	1.9	..	..	..	..	..
Flatfish						
Dover sole	0.5	..	..	..	..	78.2
Deepsea sole	1.1	3.5	0.8	3.1	4.7	0.1
Arrowtooth flounder	..	..	..	..	..	1.0
Rex sole	..	..	..	..	..	..
Roundfish						
Sablefish	8.5	62.1	102.3	53.5	13.0	200.3
Pacific cod	..	..	..	..	..	..
Pacific hake	..	..	..	..	..	0.1
Miscellaneous fish						
Roughscale rattail	154.7	32.7	64.0	173.4	178.4	8.7
Pectoral rattail	68.8	9.1	14.2	28.5	65.6	6.6
Pacific flatnose	9.7	0.1	0.1	1.0	4.0	0.1
Eelpouts	4.9	0.1	..	..	..	0.2
Other[8]	1.8	0.4	0.4	0.1	0.4	0.0
Elasmobranchii						
Deepsea skate	3.3	13.9	..	..	..	..
Black skate	..	1.5	0.7	0.9	..	..
Longnose skate	..	..	..	..	..	..
Sharks[9]	0.1	..	..	..	..	..
Invertebrates						
Tanner crab	2.0	1.9	1.3	1.5	0.1	3.1
Brittle stars	0.1	0.1	0.1	..	0.1	..
Squid	0.8	..	1.1	..	0.5	4.6
Anemones	0.1	0.1	1.6	4.4	0.1	..
Other[10]	18.1	6.7	10.5	17.6	0.8	0.1
TOTAL CATCH (Kg)	**286.6**	**201.3**	**393.1**	**353.2**	**332.6**	**402.3**

Appendix E (cont'd)

Haul No.	61	62	63	All Tows
Date	Oct. 2	Oct. 2	Oct. 2	
Start Time (24 h)	0630	0905	1135	
Duration (min)[1]	63	65	68	
Bottom Contact (min)[2]	41.5	32.4	33.8	
Area (Major, Minor)[3]	04 26	04 26	04 26	
Start N. Lat. (Deg)	49	49	49	
(Min)	54.7	54.1	54.4	
W. Long. (Deg)	127	127	127	
(Min)	58.2	57.7	58.0	
Finish N. Lat. (Deg)	49	49	49	
(Min)	55.2	55.0	51.9	
W. Long. (Deg)	128	128	128	
(Min)	2.7	1.8	1.3	
Direction (Deg. True)[4]	270	290	310	
Tow Distance (Km)[5]	4.47	4.72	4.67	
Mean Depth (m)[6]	655	715	610	
Remarks	usable	usable	usable	
Rockfish				
Shortspine thornyhead	127.4	74.2	150.7	**2030.2**
Longspine thornyhead	30.8	33.3	16.4	**3472.7**
Other rockfish[7]	..	..	3.7	**119.1**
Flatfish				
Dover sole	77.0	38.3	65.6	**1244.1**
Deepsea sole	0.7	4.8	0.1	**99.4**
Arrowtooth flounder	..	..	8.8	**69.4**
Rex sole	..	..	..	**1.0**
Roundfish				
Sablefish	80.8	50.3	32.4	**5269.6**
Pacific cod	..	..	..	**7.0**
Pacific hake	..	..	..	**42.1**
Miscellaneous fish				
Roughscale rattail	2.2	7.0	1.7	**3493.2**
Pectoral rattail	13.5	3.1	4.3	**2213.6**
Pacific flatnose	..	2.2	1.8	**398.7**
Eelpouts	0.1	2.2	0.1	**81.5**
Other[8]	0.3	0.3	1.4	**86.9**
Elasmobranchii				
Deepsea skate	7.8	4.8	3.2	**82.9**
Black skate	..	..	..	**46.8**
Longnose skate	..	..	8.3	**325.2**
Sharks[9]	..	..	0.1	**31.0**
Invertebrates				
Tanner crab	6.6	12.2	15.0	**498.4**
Brittle stars	..	..	..	**136.0**
Squid	..	7.8	9.2	**153.1**
Anemones	..	..	0.1	**66.0**
Other[10]	0.1	0.2	0.4	**222.9**
TOTAL CATCH (Kg)	**347.3**	**240.5**	**323.4**	**20190.7**

Appendix E (cont'd)

Notes pertaining to haul information.

* Denotes an estimated value based on available bridge log information.

† Estimated bottom contact time for tow #10 was based on the mean ratio of Bottom Contact time:Duration from 57 tows that had both values recorded.

1. **Duration** is the amount of time (minutes) passed between winch lockup as the fishing event begins until the time that the winch is released to start retrieving the gear

2. **Bottom contact** time represents the total time (minutes) where the bottom contact sensor reads 80° or higher, indicating that the net is on bottom.

3. **Area (Major, Minor)** refers to the identification of groundfish fishing areas along the B.C. coast into major areas, minor areas and localities (see Rutherford 1999).

4. **Tow direction** is the direction (degrees True North) at the start of the tow. Direction varies considerably as the tow is underway.

5. **Tow distance** (kilometres) calculated from time and location data recorded at intervals during each tow (see pg. 4).

6. **Mean depth** (metres) is the average of the start and end depths for each tow. A more accurate mean depth may be obtained by averaging the depths recorded at intervals during a tow.

7. **Other rockfish** includes any combination of rougheye rockfish, Pacific ocean perch, aurora rockfish, shortraker rockfish, splitnose rockfish.

8. **Other miscellaneous fish** includes any combination of slickheads, arrowtooth flounder, sculpins, filamented rattail, Pacific hake, Pacific cod, lancetfishes, deepseas smelts, blacktail snailfish, northern lampfish, Pacific viperfish, lumpfishes and snailfishes, lanternfishes, ragfish, crested ridgehead, poachers, daggertooth, longfin dragonfish, stout blacksmelt, threadfin slickhead, highfin dragonfish, dogtooth lampfish, bigfin eelpout, fish eggs, blackfin poacher, blackmouth slipskin, spiny tapirfishes, Pacific hagfish, closespine snipe eel, torrent sculpin, dwarf wrymouth, loosejaws, Pacific herring, bigeye flashlightfish, spiny dreamer, smooth dreamer, bigfin lanternfish

9. **Sharks** includes any combination of cat sharks, brown cat shark, Pacific sleeper shark

10. **Other invertebrates** includes any combination of ophiuroidea, glass sponges, starfishes, octopus, vampire squid, sponges, giant squid, commander squid, *Lithodes couesi*, jellyfish, snails and whelks, nudibranchs, sea urchins, basket stars, prawns, anthozoa, sea cucumbers, shrimp, Gorgonian corals, polychaetes, hermit crabs, bivalves, *Benthoctopus* spp., *Octopus* spp., flapjack devilfishes,, scarlet king crab, Oregon hair crab, Oregon triton, gray sand star, anthozoa, sea anemones.